NELLCOR

SERVICE MANUAL

NPB-290 Pulse Oximeter

Caution: Federal law (U.S.A.) restricts this device to sale by or on the order of a physician.

To contact Mallinckrodt's representative: In the United States, call 1.800.635.5267 or 314.654.2000; outside of the United States, call your local Mallinckrodt representative.

CE 0123

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SECTION 1: INTRODUCTION

1.1 Manual Overview
1.2 NPB-290 Pulse Oximeter Description
1.3 Related Documents

1.1 MANUAL OVERVIEW

This manual contains information for servicing the NPB-290 pulse oximeter. Only qualified service personnel should service this product. Before servicing the NPB-290, read the operator's manual carefully for a thorough understanding of how to operate the NPB-290.

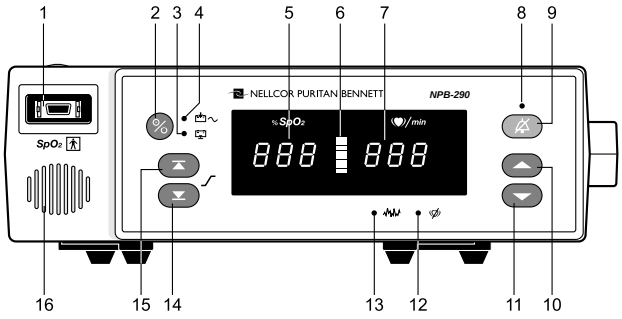
Warning: Explosion hazard. Do not use the NPB-290 pulse oximeter in the presence of flammable anesthetics.

1.2 NPB-290 PULSE OXIMETER DESCRIPTION

The Nellcor NPB-290 pulse oximeter is intended for continuous, noninvasive monitoring of functional oxygen saturation of arterial hemoglobin (SpO_2), and pulse rate (measured by SpO_2 sensor).

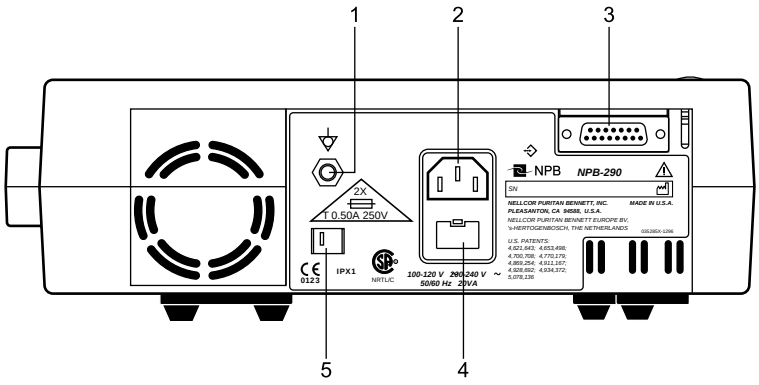
The monitor is intended for use on adult, pediatric, and neonatal patients in all hospital areas, hospital-type facilities, and in the home environment. It may be used during intra-hospital transport when powered by its internal battery.

Digital displays are provided for oxygen saturation and pulse rate, and a 10-segment light-emitting diode (LED) bar indicates pulse amplitude.
The NPB-290 can operate on AC or rechargeable internal battery power. The controls and indicators for the NPB-290 are illustrated in Figure 1-1 and Figure 1-2.



1. SpO_2 Sensor Port
2. Power On/Off Button
3. Low Battery Indicator
4. AC Power Indicator
5. %SpO_2 Display
6. Pulse Amplitude Indicator
7. Pulse Rate Display
8. Alarm Silence Indicator
9. Alarm Silence Button
10. Adjust Up Button
11. Adjust Down Button
12. Pulse Search Indicator
13. Motion Indicator
14. Lower Alarm Limit Button
15. Upper Alarm Limit Button
16. Speaker

Figure 1-1: NPB-290 Front Panel



1. Equipotential Terminal
2. AC Connector
3. Data Port
4. Fuse Drawer
5. Supply Voltage Selector Switch

Figure 1-2: NPB-290 Rear Panel

1.3 RELATED DOCUMENTS

To perform test and troubleshooting procedures and to understand the principles of operation and circuit analysis sections of this manual, you must know how to operate the monitor. Refer to the NPB-290 operator's manual. To understand the various Nellcor sensors that work with the monitor, refer to directions for use for individual sensors.

SECTION 2: ROUTINE MAINTENANCE

2.1 Cleaning
2.2 Periodic Safety and Functional Checks
2.3 Battery

2.1 CLEANING

Caution: Do not immerse the NPB-290 or its accessories in liquid or clean with caustic or abrasive cleaners. Do not spray or pour any liquid on the monitor or its accessories.

To clean the NPB-290, dampen a cloth with a commercial, nonabrasive cleaner and wipe the exterior surfaces lightly. Do not allow any liquids to come in contact with the power connector, fuse holder, or switches. Do not allow any liquids to penetrate connectors or openings in the instrument cover. Wipe sensor cables with a damp cloth. For sensors, follow the individual directions for use.

2.2 PERIODIC SAFETY AND FUNCTIONAL CHECKS

The NBP-290 requires no calibration.

The battery should be replaced at least every 24 months (paragraph 6.6).

The following checks should be performed at least every 24 months by a qualified service technician.

2.2.1 Periodic Safety Checks

1. Inspect the equipment for mechanical and functional damage.
2. Inspect safety labels for legibility. If the labels are not legible, contact Mallinckrodt Technical Services Department or your local Mallinckrodt representative.

2.2.2 Functional Checks

If the monitor has been visibly damaged or subjected to mechanical shock (for example, if dropped), perform the performance tests, refer to paragraph 3.3.

The following checks should be performed at least every 2 years by a qualified service technician.

1. Perform the electrical safety tests detailed in paragraph 3.4. If the unit fails these electrical safety tests, refer to Section 6, *Troubleshooting*.
2. Inspect the fuses for proper value and rating (F1 & F2 = 0.5 amp, 250 volts).

2.3 BATTERY

Mallinckrodt recommends replacing the instrument battery every 2 years. When the NPB-290 is going to be stored for 2 months or more, remove the battery. To replace or remove the battery, refer to Section 6, *Disassembly Guide*.

If the NPB-290 has been stored for more than 30 days, charge the battery as described in paragraph 3.3.1. A fully discharged battery requires 14 hours to receive a full charge when the NPB-290 is in the standby mode and 18 hours if the NPB-290 is in use. The battery is being charged anytime that the instrument is plugged into AC power.

SECTION 3: PERFORMANCE VERIFICATION

3.1 Introduction
3.2 Equipment Needed
3.3 Performance Tests
3.4 Safety Tests

3.1 INTRODUCTION

This section discusses the tests used to verify NPB-290 performance following repairs or during routine maintenance. All tests can be performed without removing the NPB-290 cover.

If the NPB-290 fails to perform as specified in any test, repairs must be made to correct the problem before the monitor is returned to the user.

3.2 EQUIPMENT NEEDED

Equipment	Description
Digital multimeter (DMM)	Fluke Model 87 or equivalent
Durasensor® oxygen transducer	DS-100A
Oxisensor® *II* oxygen transducer	D-25
Pulse oximeter tester	SRC-2
Safety analyzer	Must meet current AAMI ES1/1993 & IEC 601-1/1998 specifications
Sensor extension cable	SCP-10 or MC-10
Serial interface cable	Refer to paragraph 10.3
Stopwatch	Manual or electronic

3.3 PERFORMANCE TESTS

The battery should be charged before the monitor is repaired whenever possible.

Note: This section is written using Mallinckrodt factory-set defaults. If your institution has pre-configured custom defaults, those values will be displayed. Factory defaults can be reset using the configuration procedure described in paragraph 4.4.5.

3.3.1 Battery Charge

Perform the following procedure to fully charge the battery.

1. Connect the monitor to an AC power source.
2. Verify that the monitor is off and that the AC Power/Battery Charging indicator is lit.

3. Charge the battery for at least 14 hours.

3.3.2 Performance Tests

The power-up performance tests (3.3.2.1 and 3.3.2.2) verify the following monitor functions:

- 3.3.2.1 Power-On Self-Test
- 3.3.2.2 Factory Power-On Defaults and Alarm Limit Ranges

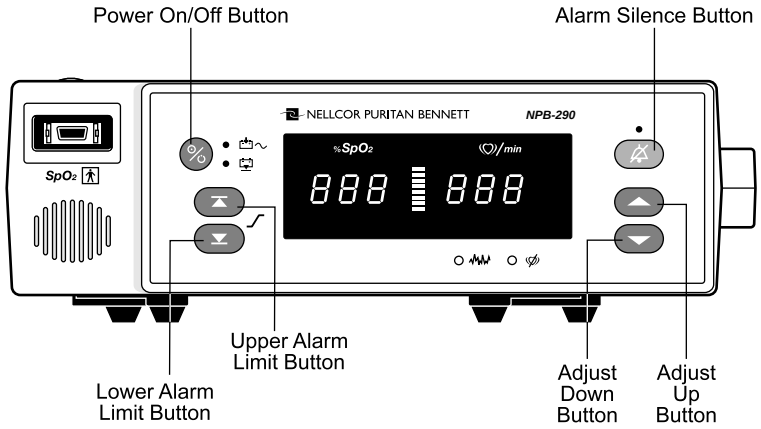


Figure 3-1: NPB-290 Controls

3.3.2.1 Power-On Self-Test (POST)

Note: See Figure 3-1 for the location of the NPB-290 controls.

1. Connect the monitor to an AC power source. Verify the AC Power/Battery Charging indicator is lit.

2. Do not connect any input cables to the monitor.
3. Observe the front panel of the monitor. With the monitor off, press the Power On/Off button. Verify that the monitor performs the following sequence:
   a. Red "8.8.8." is displayed in both windows for a few seconds and the 10-segment blip bar is completely illuminated in green. Only the AC Power Indicator is illuminated.

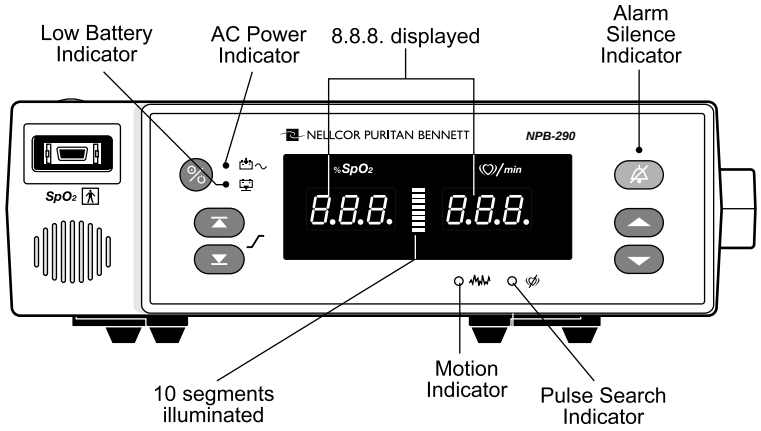


Figure 3-2: Power-On Self-Test Display

b. The "8.8.8." displayed in both windows turns green, the 10-segment blip bar is completely illuminated in green, and all LEDs are illuminated as shown in Figure 3-2.

c. The software version is displayed and all LEDs are illuminated.

d. A 1-second POST beep sounds, 3 dashes are displayed in each window, and all LEDs are off except the AC Power LED.

Note: When a sensor is connected, a zero is displayed in each window, a 1-second Power-On Self-Test (POST) beep sounds and the Pulse Search LED is illuminated along with the AC Power/Battery Charging LED.

e. The NPB-290 begins normal operation if a sensor is connected. Without a sensor, the monitor will display 3 dashes in each window.

3.3.2.2 Factory Power-On Defaults and Alarm Limit Ranges

Note: See Figure 3-1 for the location of the NPB-290 controls.

Note: When observing or changing default limits, a 3-second timeout is in effect, that is, if no action is taken within 3 seconds, the monitor automatically returns to the normal mode.

1. Turn the monitor on by pressing the Power On/Off button.

   a. Wait for POST to be completed.

   b. Press and release the Upper Alarm Limit button.

   c. Verify that the monitor emits a single beep and the %SpO2 display indicates a high alarm limit of "100" for about 3 seconds.

   d. Verify that three dashes are displayed at the top of the pulse rate display. See Figure 3-3.

Note: The location of the three dashes indicates the type of alarm limit that is being adjusted. Three dashes in the top of the display window indicate a high alarm limit and three dashes in the bottom of the display window indicate a low alarm limit.

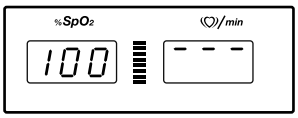


Figure 3-3: Adjusting High %SpO2 Alarm Limit

2. Press the Upper Alarm Limit button. Within 3 seconds press and hold the Adjust Down button. Verify the %SpO2 display reduces to a minimum of "85."

Note: A decimal point to the right of the value in either display indicates that the alarm limits are not power-on default values.

3. Press the Lower Alarm Limit button. Verify that the monitor emits a single beep and that the %SpO2 display indicates an alarm limit of "85" for 3 seconds. Verify that three dashes are displayed at the bottom of the pulse rate display. See Figure 3-4.

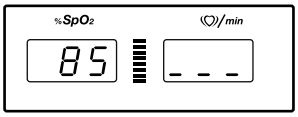


Figure 3-4: Adjusting Low %SpO2 Alarm Limit

4. Press the Lower Alarm Limit button. Within 3 seconds press and hold the Adjust Down button and verify that the %SpO2 display reduces to a minimum of "20." Press and hold the Adjust Up button and verify that the %SpO2 display cannot be raised past the upper alarm limit setting of "85."

5. Press the Upper Alarm Limit button two times rapidly (twice within 3 seconds). Verify that the monitor emits two beeps, the pulse rate display indicates an alarm limit of "170," and that the %SpO2 display window shows three dashes at the top for about 3 seconds. See Figure 3-5.

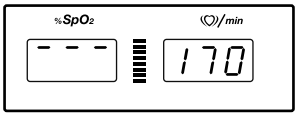


Figure 3-5: Adjusting High Pulse Rate Alarm Limit

6. Press the Upper Alarm Limit button two times rapidly. Within 3 seconds press and hold the Adjust Down button. Verify that the pulse rate display reduces to a minimum of "40." See Figure 3-6.

7. Press the Lower Alarm Limit button two times rapidly. Verify that the pulse rate display indicates an alarm limit of "40" and that the %SpO2 display shows three dashes at the bottom for 3 seconds.

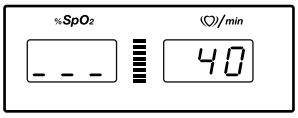


Figure 3-6: Adjusting Low Pulse Rate Alarm Limit

8. Press the Lower Alarm Limit button two times rapidly. Within 3 seconds press and hold the Adjust Down button. Verify that the pulse rate display reduces to a minimum of "30."
9. Press the Lower Alarm Limit button two times rapidly. Within 3 seconds press and hold the Adjust Up button. Verify that the pulse rate display cannot be adjusted above "40."
10. Press the Power On/Off button to turn the unit off. Turn the unit back on.
11. Press and release the Upper Alarm Limit button. Verify that the %SpO_2 display indicates an alarm limit of "100."
12. Press and release the Lower Alarm Limit button. Verify that the %SpO_2 display indicates an alarm limit of "85."
13. Press the Upper Alarm Limit button two times rapidly. Verify that the pulse rate display indicates an alarm limit of "170."
14. Press the Lower Alarm Limit button two times rapidly. Verify that the pulse rate display indicates an alarm limit of "40."
15. Press the Power On/Off button to turn the monitor off.

3.3.3 Hardware and Software Tests

Hardware and software testing includes the following tests:

- 3.3.3.1 Operation with a Pulse Oximeter Tester
- 3.3.3.2 General Operation

3.3.3.1 Operation with a Pulse Oximeter Tester

Operation with an SRC-2 pulse oximeter tester includes the following tests:

- 3.3.3.1.1 Alarms and Alarm Silence
- 3.3.3.1.2 Alarm Volume Control
- 3.3.3.1.3 Pulse Tone Volume Control
- 3.3.3.1.4 Dynamic Operating Range
- 3.3.3.1.5 Nurse Call
- 3.3.3.1.6 Analog Output
- 3.3.3.1.7 Operation on Battery Power

3.3.3.1.1 Alarms and Alarm Silence

1. Connect the SRC-2 pulse oximeter tester to the sensor-input cable and connect the cable to the monitor. Refer to SRC-2 Operator's manual. Set the SRC-2 switches as follows:

SWITCH	POSITION
RATE	38
LIGHT	HIGH 1
MODULATION	OFF
RCAL/MODE	RCAL 63/LOCAL

2. Press the Power On/Off button to turn the monitor on. After the normal power-up sequence, verify that the pulse rate initially indicates zeroes.

Note: The pulse amplitude indicator may occasionally indicate a step change as the monitor is in the pulse search mode.

3. Set the modulation switch on the SRC-2 to HIGH.

4. Verify that the following monitor reactions:

   a. The pulse amplitude indicator begins to track the artificial pulse signal from the SRC-2.

   b. The pulse tone is heard.

   c. Zeroes are displayed in the %SpO_2 and pulse rate displays.

   d. After about 10 to 20 seconds, the monitor displays oxygen saturation and pulse rate as specified by the tester. Verify that the values are within the following tolerances:

      - Oxygen saturation range 79% to 83%
      - Pulse rate range 37 to 39 bpm

   e. The audible alarm sounds and both the %SpO_2 and pulse rate displays flash the values in red. This is an indication that both parameters have violated the default alarm limits.

5. Press and hold the Alarm Silence button located on the front of the monitor for less than 3 seconds. Verify that the pulse rate display indicates "SEC" and the %SpO_2 display indicates "60" while the Alarm Silence button is pressed. The alarm is silenced when the button is released. See Figure 3-7.

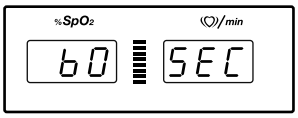


Figure 3-7: Alarm Silence Duration

6. Release the Alarm Silence button. Verify the following:

   a. The alarm remains silenced.

   b. The Alarm Silence indicator lights.

   c. The %SpO_2 and pulse rate displays resume flashing.

   d. The pulse tone is still audible.

   e. The audible alarm returns after approximately 60 seconds.

7. While pressing the Alarm Silence button, press the Adjust Down button until the %SpO_2 display indicates "30."

8. Press the Adjust Up button and verify that the displays indicate 60 SEC, 90 SEC, 120 SEC, and OFF. Release the button when the display indicates "OFF."

9. Press the Alarm Silence button again and verify that the Alarm Silence indicator flashes.

10. Wait approximately 3 minutes. Verify that the alarm does not return.
11. After 3 minutes ± 10 seconds, the alarm silence reminder beeps three times, and continues to do so at 3-minute intervals.

3.3.3.1.2 Alarm Volume Control

After completing the procedure in paragraph 3.3.3.1.1:

1. Press and hold the Alarm Silence button for more than 3 seconds. Verify the following:
   a. "OFF" is displayed for approximately 3 seconds.
   b. After 3 seconds:
      - a steady tone is heard at the default alarm volume setting
      - the %SpO2 display indicates "VOL." See Figure 3-8.
      - the pulse rate display indicates the default setting of 5.

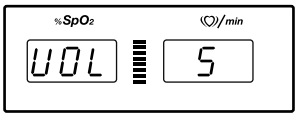


Figure 3-8: Alarm Volume Display

2. Press the Adjust Down button until an alarm volume setting of 1 is displayed. Verify that the volume of the alarm has decreased but is still audible.
3. Press the Adjust Up button to increase the alarm volume setting to a maximum value of 10. Verify that the volume increases.
4. Press the Adjust Down button until a comfortable audio level is attained.
5. Release the Alarm Silence button. The tone stops.

3.3.3.1.3 Pulse Tone Volume Control

1. When a valid pulse has been acquired, press the Adjust Up button and verify that the sound level of the beeping pulse tone increases.
2. Press the Adjust Down button and verify that the beeping pulse tone decreases until it is no longer audible.
3. Press the Adjust Up button to return the beep volume to a comfortable level.

3.3.3.1.4 Dynamic Operating Range

The following test sequence verifies proper monitor operation over a range of input signals:

1. Turn the instrument off and connect the SRC-2 to the NPB-290. Turn the NPB-290 on.
2. Place the SRC-2 in the RCAL 63/LOCAL mode.
3. Set the SRC-2 as indicated in Table 3-1. Verify that the NPB-290 readings are within the indicated tolerances. Allow the monitor several seconds to stabilize the readings.

Note: An asterisk (*) indicates values that produce an alarm. Press the Alarm Silence button to silence the alarm.

Table 3-1: Dynamic Operating Range

SRC-2 Settings			NPB-290 Indications	
Rate	**Light**	**Modulation**	**SpO2**	**Pulse Rate**
38	HIGH2	LOW	79 - 83*	37 - 39*
112	HIGH1	HIGH	79 - 83*	110 - 114
201	LOW	LOW	79 - 83*	195 - 207*
201	LOW	HIGH	79 - 83*	195 - 207*

3.3.3.1.5 Nurse Call

Note: The Nurse Call tests must be performed with the instrument operating on AC power.

1. Connect the negative lead of a voltmeter to pin 10 and the positive lead to pin 11 of the data port on the back of the instrument (Figure 10-1). Ensure that the audible alarm is not silenced or turned off.
2. Set the pulse rate switch of the SRC-2 to create an alarm condition. Refer to the SRC-2 Operator's manual. Verify that an output voltage at pins 10 and 11 between +5 and +12 volts DC.
3. Press the Alarm Silence button. With no active audible alarm, the output voltage at pins 10 and 11 must be between -5 and -12 volts DC.
4. With the instrument in an alarm condition, use an ohmmeter to verify that there is no continuity between pins 8 and 15 and that there is continuity between pins 7 and 15.
5. Adjust the alarm limits so that there is no alarm condition. Use an ohmmeter to verify that there is continuity between pins 8 and 15 and that there is no continuity between pins 7 and 15.

3.3.3.1.6 Analog Output

Note: The Analog Output tests must be performed with the instrument operating on AC power.

1. Connect the negative lead of a voltmeter to pin 10 and the positive lead to pin 6 of the data port located on the back of the instrument (Figure 1-2).
2. Turn the instrument off, then turn it back on.
3. Verify that the output voltage is 0.000 ± 0.025 volts DC, then after about a minute verify that the voltage has increased to +1.000 ± 0.025 volts DC.
4. Move the positive lead to pin 13 and repeat steps 2 and 3.
5. Move the positive lead to pin 14 and repeat steps 2 and 3.
6. Disconnect the voltmeter from the instrument.

3.3.3.1.7 Operation on Battery Power

1. Turn the instrument on using AC power.
2. Disconnect the instrument from AC and verify the AC Power Indicator turns off.
3. Verify the instrument continues monitoring normally and that the Low Battery Indicator is not lit.

Note: If the Low Battery Indicator is lit, perform the procedure in paragraph 3.3.1.

4. Connect the instrument to AC and verify that the AC Power Indicator lights and that the instrument is monitoring normally.

3.3.3.2 General Operation

The following tests are an overall performance check of the system:

- LED Excitation Test
- Monitor Operation with a Live Subject

3.3.3.2.1 LED Excitation Test

This procedure uses normal system components to test circuit operation. A Nellcor *Oxisensor® II* oxygen transducer, model D-25, is used to examine LED intensity control. The red LED is used to verify intensity modulation caused by the LED intensity control circuit.

1. Connect the monitor to an AC power source.
2. Connect an SCP-10 or MC-10 sensor input cable to the monitor.
3. Connect a D-25 sensor to the sensor-input cable.
4. Press the Power On/Off button to turn the monitor on.
5. Leave the sensor open with the LEDs and photodetector visible.
6. After the monitor completes its normal power-up sequence, verify that the sensor LED is brightly lit.
7. Slowly move the sensor LED in close to the photodetector element of the sensor. As the LED approaches the photodetector, verify that the LED intensity decreases.
8. Open the sensor and notice that the LED intensity increases.
9. Repeat step 7 and the intensity will again decrease. This variation is an indication that the microprocessor is in proper control of LED intensity.
10. Turn the NPB-290 off.

3.3.3.2.2 Monitor Operation with a Live Subject

Pulse oximetry involves connecting the monitor to a live subject for a qualitative test.

1. Ensure that the monitor is connected to an AC power source.

2. Connect an SCP-10 or MC-10 sensor input cable to the monitor.
3. Connect a Nellcor *Durasensor*® oxygen transducer, model DS-100A, to the sensor input cable.
4. Clip the DS-100A to an adult subject as recommended in the sensor directions for use.
5. Press the Power On/Off button to turn the monitor on and verify that the monitor is operating.
6. The monitor should stabilize on the subject's physiological signal in about 15 to 30 seconds. Verify that the saturation and heart rates are reasonable for the subject.

3.4 SAFETY TESTS

NPB-290 safety tests meet the standards of, and are performed in accordance with, IEC 601-1 (EN 60601-1, Second Edition, 1988; Amendment 1, 1991-11, Amendment 2, 1995-03) and UL 2601-1 (August 18, 1994), for instruments classified as Class 1 and TYPE BF, and AAMI Standard ES1 (ANSI/AAMI ES1 1993).

3.4.1 Ground Integrity

This test checks the integrity of the power cord ground wire from the AC plug to the instrument chassis ground. The current used for this test is $\leq$ 6 volts RMS, 50 or 60 Hz, and 25 A.

1. Connect the monitor AC power cord to the analyzer as recommended by the analyzer operating instructions.
2. Connect the analyzer resistance input lead to the equipotential terminal (grounding lug) on the rear panel of the instrument. See Figure 1-2. Verify that the analyzer indicates 100 milliohms or less.

3.4.2 Electrical Leakage

The following tests verify the electrical leakage of the monitor:

- Earth Leakage Current
- Enclosure Leakage Current
- Patient Applied Risk Current
- Patient Isolation Risk Current (Mains Voltage on the Applied Part)

Note**:** For the following tests, ensure the AC switch on the rear of the instrument is configured for the AC voltage being supplied.

3.4.2.1 Earth Leakage Current

This test is in compliance with IEC 601-1 (earth leakage current) and AAMI Standard ES1 (earth risk current). The applied voltage for AAMI ES1 is 120 volts AC, 60 Hz; for IEC 601-1 the voltage is 264 volts AC, 50 to 60 Hz. All measurements shall be made with the power switch in both the "On" and "Off" positions. Refer to Table 3-2.

1. Connect the monitor AC plug to the electrical safety analyzer as recommended by the analyzer operating instructions.
2. The equipotential terminal is not connected to ground.

Table 3-2: Earth Leakage Current Limits

AC Polarity	Line Cord	Neutral Cord	Leakage Current
Normal	Closed	Closed	500 µA
Reversed	Closed	Closed	500 µA
Normal	Open	Closed	1000 µA
Normal	Closed	Open	1000 µA

3.4.2.2 Enclosure Leakage Current

This test is in compliance with IEC 601-1 (enclosure leakage current) and AAMI Standard ES1 (enclosure risk current). This test is for ungrounded enclosure current, measured between enclosure parts and earth. The applied voltage for AAMI/ANSI is 120 volts AC, 60 Hz, and for IEC 601-1 the applied voltage is 264 volts AC, 50 to 60 Hz. Refer to Table 3-3.

1. Connect the monitor AC plug to the electrical safety analyzer as recommended by the analyzer operating instructions.
2. Place a 200-cm^2 foil in contact with the instrument case, making sure the foil is not in contact with any metal parts of the enclosure that may be grounded. Measure the leakage current between the foil and earth.

Note: The analyzer leakage indication must not exceed values listed Table 3-3.

Table 3-3: Enclosure Leakage Current Limits

AC Line Cord	Neutral Line Cord	Power Line Ground Cable	IEC 601-1	AAMI/ANSI ES1 Standard
Closed	Closed	Closed	100 µA	100 µA
Closed	Closed	Open	500 µA	300 µA
Closed	Open	Closed	500 µA	300 µA
Open	Closed	Closed	500 µA	100 µA
Open	Open	Closed	500 µA	300 µA
Open	Closed	Open	500 µA	300 µA

3.4.2.3 Patient Applied Risk Current

This test is in compliance with AAMI Standard ES1 (patient applied risk current), and IEC 601-1 (patient auxiliary current). The leakage current is measured between any individual patient connection and power (earth) ground. The applied voltage for AAMI/ANSI is 120 volts AC, 60 Hz, and for IEC 601-1 the applied voltage is 264 volts AC, 50 to 60 Hz. Refer to Table 3-4.

1. Configure the electrical safety analyzer as follows:

   Function: Patient Leakage
   Range: µA
2. Connect the monitor AC plug to the electrical safety analyzer as recommended by the analyzer operating instructions for Patient Leakage Current.
3. Connect the patient leakage input lead of the electrical safety analyzer to all pins of the monitor's patient cable at the end of the cable.
4. The equipotential terminal is not connected to ground.
5. All functional earth terminals are not connected to ground.
6. Measure the leakage current between the patient connector and earth.

Table 3-4: Patient Leakage Current Limits

AC Line Polarity	Neutral Line	Power Line Ground Cable	IEC 601-1	AAMI/ANSI ES1 Standard
Normal	Closed	Closed	100 µA	10 µA
Normal	Open	Closed	500 µA	50 µA
Normal	Closed	Open	500 µA	50 µA
Reverse	Closed	Closed	100 µA	10 µA
Reverse	Open	Closed	500 µA	50 µA
Reverse	Closed	Open	500 µA	50 µA

3.4.2.4 Patient Isolation Risk Current - (Mains Voltage on the Applied Part)

This test is in compliance with AAMI Standard ES1 (patient isolation risk current [sink current]), and IEC 601-1 (patient leakage current). Patient Leakage Current is the measured value in a patient connection if mains voltage is connected to that patient connection. The applied voltage for AAMI/ANSI is 120 volts AC, 60 Hz, and for IEC 601-1 the applied voltage is 264 volts AC, 50 to 60 Hz.

Warning: AC mains voltage will be present on the patient cable terminals during this test. Exercise caution to avoid electrical shock hazard.

1. Configure the electrical safety analyzer as follows:

   Function: Patient Leakage (Mains On Applied Part)
   Range: µA

2. Connect the monitor AC plug to the electrical safety analyzer as recommended by the operating instructions for patient sink (leakage) current.
3. Connect the patient leakage input lead of the electrical safety analyzer to all connectors in the patient cable at the patient end of the cable.
4. The equipotential terminal is not connected to ground.
5. All functional earth terminals are not connected to ground.
6. The analyzer leakage current must not exceed the values shown in Table 3-5.

Table 3-5: Patient Leakage Current Test Configurations - Mains Voltage on the Applied Part

AC Line Polarity	Neutral Line	Power Line Ground Cable	IEC 601-1	AAMI/ANSI ES1 Standard
Normal	Closed	Closed	5 mA	50 µA
Reverse	Closed	Closed	5 mA	50 µA

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SECTION 4: AUDIBLE ALARM SETTINGS AND SERVICE MENU

4.1 Introduction
4.2 Audible Alarm Settings
4.3 Operator's Menu Options
4.4 Service Menu Options

4.1 INTRODUCTION

This section discusses use of the service menu to reconfigure power-on default values, and how to control the behavior of the audible alarm.

4.2 AUDIBLE ALARM SETTINGS

The following paragraphs describe how to change the behavior of the audible alarm. Operators can select the volume of the alarm and the duration of alarm silence. Controls for the NPB-290 are shown in Figure 4-1.

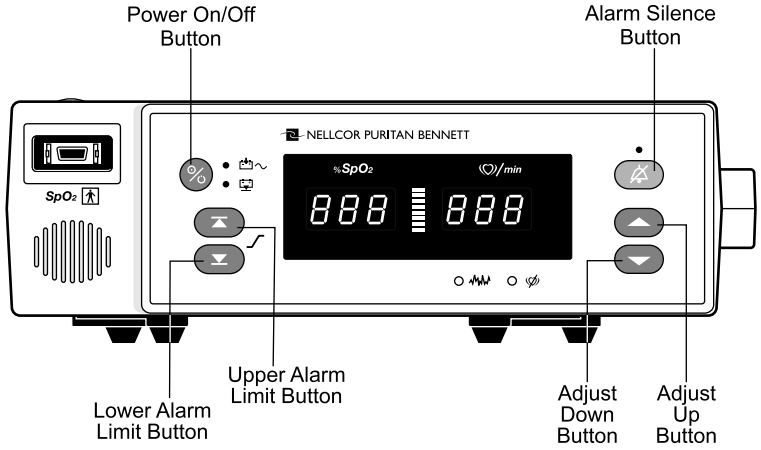

Figure 4-1: NPB-290 Controls

4.2.1 Alarm Silence State

Press the Alarm Silence button to silence the alarm. Press the button a second time to turn the alarm back on.

4.2.2 Alarm Silence Duration

1. Press and hold the Alarm Silence button for less than 3 seconds.
2. Before 3 seconds have passed, the Adjust Up or Adjust Down button can be used to change the duration of the alarm silence. The alarm duration can be set to 30, 60, 90, or 120 seconds, or the alarm can be turned to Off.

4.2.3 Alarm Volume

1. Press and hold the Alarm Silence button for more than 3 seconds.
2. After 3 seconds, while still pressing the Alarm Silence button, the Adjust Up or Adjust Down button can be used to select alarm volumes from 1 to 10. Select a level that is suitable for the monitor's location.

4.3 OPERATOR'S MENU OPTIONS

The menu items listed below are options that are available to the operator. These options can be used to print or clear trend data, and to change the configuration of data from the data port. Changes can be made in menu options 1 through 5 while monitoring a patient. Menu items beyond 5 cannot be accessed when a sensor is connected to the instrument. Unless changes are saved as power-on default values, they will be lost when the NPB-290 is turned off. When the instrument is turned on again, it will begin to use the power-on default values that have been stored. Factory-set power-on default values are listed in Table 4-2.

4.3.1 Accessing Menu Items

1. Menu items can be accessed at any time by pressing the Upper and Lower Alarm Limit buttons simultaneously for at least 3 seconds. Menu options have been accessed when a "1" appears in the pulse rate display.

2. Pressing the Adjust Up or Adjust Down button selects the menu item number. Menu items 3, 5, 8, and 11 have options within them that can be selected by first pressing the Upper Alarm Limit button, and then pressing the Adjust Up or Adjust Down key. The option being selected is displayed in the %SpO_2 display window.

Note: Service menu items numbered above 5 cannot be accessed if a sensor is connected to the monitor.

3. Once adjustments have been made within a menu item, the Upper Alarm Limit button can be used to initiate the current selection. To save the current settings as power-on default values, refer to the procedure outlined in paragraph 4.4.4.

4. Menu options can be exited without making changes by pressing the Lower Alarm Limit button. If a period of 10 seconds passes with no button presses, the instrument will exit the service menu, go to normal monitoring, and no changes will have been made.

4.3.2 Menu Item 1 (Trend Print)

Trend data can be viewed (if connected to a PC), or a trend printout can be made, if the Upper Alarm Limit button is pressed when menu item 1 is displayed. For more information about trend printouts, refer to paragraph 10.4.

4.3.3 Menu Item 2 (Trend Clear)

When menu item 2 is selected, trend data that is available through the use of menu item 1 will be deleted when the Upper Alarm Limit button is pressed and held until three beeps are heard.

4.3.4 Menu Item 3 (Language Selection)

1. Seven languages are available for data output to the data port. Once menu item 3 has been accessed, press the Upper Alarm Limit button. Then press the Adjust Up or Adjust Down button until the desired number is displayed in the %SpO_2 window. Table 4-1 lists the languages and their numbers.

Table 4-1: Language Selection

Number	Language
0	English
1	French
2	German
3	Italian
4	Spanish
5	Dutch
6	Portuguese

2. When the desired option is indicated in the %SpO2 display, press the Upper Alarm Limit button to initiate the current selection.

4.3.5 Menu Item 4 (Baud Rate)

1. Baud rates of 2400, 9600, and 19200 can be selected by first pressing the Upper Alarm Limit button, then using the Adjust Up or Adjust Down button to select the desired baud rate. The baud rates will be displayed in the %SpO2 window as 24, 96, or 192.

2. When the desired option is indicated in the %SpO2 display, press the Upper Alarm Limit button to initiate the current selection.

4.3.6 Menu Item 5 (EPP mode)

1. This menu item is used to change the method of sending data to the data port. Three options -- 0, 1, or 2 -- can be accessed by first pressing the Upper Alarm Limit button, then using the Adjust Up or Down button to scroll to the desired number.

   - Option "0" enables ASCII. This option would be used to send data to a printer or to receive instructions from a computer.
   - Option "1" sends data from the data port that can be used by the Nellcor *Oxinet* II system and with *Score*™ Software.

   Note: When using *Score*™ software use the latest version. Contact Mallinckrodt's Technical Services Department or your local Mallinckrodt representative to determine the latest version of *Score* software.

   - Option "2" is intended for Mallinckrodt use only.

2. When the desired option is indicated in the %SpO2 display, press the Upper Alarm Limit button to initiate the current selection.

Note: Menu items greater than 5 cannot be accessed when a valid sensor is connected to the unit.

4.4 SERVICE MENU OPTIONS

Service menu options can be accessed only when the sensor is disconnected from the instrument. Only qualified service personnel should access these options. Refer to paragraph 4.3.1 for instructions on how to access the menu options and make selections within them.

Note: To reach menu item 8, two invalid tones will be heard when passing through menu items 6 and 7. An invalid tone is a single low-pitched tone.

4.4.1 Menu Item 6 (Not Displayed)

4.4.2 Menu Item 7 (Not Displayed)

4.4.3 Menu Item 8 (Nurse Call Polarity)

A negative voltage is provided on pin 10 and a positive voltage on pin 11 that can be used to drive a Nurse Call alarm. This voltage will be either -5 volts DC to -12 volts DC or +5 volts DC to +12 volts DC, depending on the state of the audible alarm. An audible alarm causes the voltage to change polarity. Using menu item 8, a choice can be made to make the voltage go either positive or negative during an audible alarm.

1. Two options, 0 or 1, can be accessed by first pressing the Upper Alarm Limit button, then using the Adjust Up or Down button to scroll to the desired number.
   - Selecting option "0" makes the voltage negative during an audible alarm and positive when there is no audible alarm.
   - Selecting option "1" makes the voltage positive during an audible alarm and negative when there is no audible alarm.
2. When the desired option is indicated in the %SpO_2 display, press the Upper Alarm Limit button to save the current selection.

4.4.4 Menu Item 9 (Save Current Values as Power-On Default)

If menu item 9 is selected, the current values for alarm limits, alarm volume, pulse beep volume, audible alarm silence duration, alarm silence behavior, communications protocol, and baud rate will be saved as the power-on default settings. To save new values as the current power-on default values, press the Upper Alarm Limit button. Three tones will sound to indicate that the changes have been accepted.

The following values are not allowed to be saved as power-on default values.

- Alarm Silence Duration of Off
- Low %SpO_2 alarm limits less than 80%.

If an invalid tone is heard instead of the triple beep, the current settings were not changed. An invalid tone is a single low-pitched tone.

Note: Current values will not be stored in memory as defaults if power is interrupted before exiting this menu option.

Note: When the operator changes an alarm limit to a value other than a power-on default value, a decimal point is displayed to the right of the parameter whose alarm limit was changed.

4.4.5 Menu Item 10 (Return to Default Settings)

Menu item 10 resets the monitor to factory default settings as shown in Table 4-2, three confirmation tones will be heard.

After menu item 10 has been selected, cycle power to the NPB-290 and verify that the factory default values have been reinstated.

Table 4-2: Factory Default Settings

Parameter	Default Value
Alarm Silence Behavior	0 (Off with reminder)
Alarm Silence Duration	60 seconds
Alarm Volume	Level 5
Baud Rate	9600
Data Port Format	Real-time ASCII
Nurse Call Polarity	Normally Low
Pulse beep volume	Level 4
Pulse rate High	170 bpm
Pulse rate Low	40 bpm
SpO_2 High	100%
SpO_2 Low	85%

4.4.6 Menu Item 11 (Alarm Silence Behavior)

1. This menu item is used to change alarm silence behavior. Three options (0, 1, or 2) can be accessed by first pressing the Upper Alarm Limit button, then using the Adjust Up or Down button to scroll to the desired number.

   - Option "0" allows the operator to select Alarm Silence Off. There will be a reminder tone every 3 minutes.
   - Option "1" allows the operator to select Alarm Silence Off. There will be **no** reminder tone.
   - Option "2" does not allow the operator to select Alarm Silence Off.

2. When the desired option is indicated in the $\%SpO_2$ display, press the Upper Alarm Limit button to save the current selection.

Note: The low battery audible alarm cannot be disabled.

4.4.7 Menu Item 12

Do not use. For use by Mallinckrodt Customer Service Engineer.

4.4.8 Menu Item 13

Do not use. For use by Mallinckrodt Customer Service Engineer.

4.4.9 Menu Item 14 (Calibration Signal)

Menu item 14 will initiate the calibration signal. The calibration signal will begin at 0.0 volts DC and hold that point for 60 seconds. It will then jump up to its maximum of +1.0 volt DC and hold that value for 60 seconds. The third part of the calibration signal is a stair-step signal. The stair-step signal starts at 0.0 volts DC and increases up to +1.0 volt DC in 0.1-volt increments. Each increment will be held for 1 second. Refer to Table 10-1 for Data port pin outs.

SECTION 5: TROUBLESHOOTING

5.1 Introduction
5.2 How to Use this Section
5.3 Who Should Perform Repairs
5.4 Replacement Level Supported
5.5 Obtaining Replacement Parts
5.6 Troubleshooting Guide
5.7 Error Codes

5.1 INTRODUCTION

This section explains how to troubleshoot the NPB-290. Tables are supplied that list possible monitor difficulties, along with probable causes, and recommended actions to correct each difficulty.

5.2 HOW TO USE THIS SECTION

Use this section in conjunction with Section 3, *Performance Verification*, and Section 7, *Spare Parts*. To remove and replace a part you suspect is defective, follow the instructions in Section 6, *Disassembly Guide*. The circuit analysis in Section 11, *Technical Supplement,* offers information on how the monitor functions.

5.3 WHO SHOULD PERFORM REPAIRS

Only qualified service personnel should open the monitor housing, remove and replace components, or make adjustments. If your medical facility does not have qualified service personnel, contact Mallinckrodt Technical Services or your local Mallinckrodt representative.

5.4 REPLACEMENT LEVEL SUPPORTED

The replacement level supported for this product is to the printed circuit board (PCB) and major subassembly level. Once you isolate a suspected malfunctioning PCB, follow the procedures in Section 6, *Disassembly Guide,* to replace the PCB with a known good PCB. Check to see if the symptom disappears and that the monitor passes all performance tests. If the symptom persists, swap back the replacement PCB with the suspected malfunctioning PCB (the original PCB that was installed when you started troubleshooting) and continue troubleshooting as directed in this section.

5.5 OBTAINING REPLACEMENT PARTS

Mallinckrodt Technical Services provides technical assistance information and replacement parts. To obtain replacement parts, contact Mallinckrodt or your local Mallinckrodt representative. Refer to parts by the part names and part numbers listed in Section 7, *Spare Parts*.

5.6 TROUBLESHOOTING GUIDE

Table 5-1 categorizes problems with the NPB-290. Refer to the paragraph indicated for further troubleshooting instructions.

Note: Taking the recommended actions discussed in this section will correct the majority of problems you will encounter. However, problems not covered here can be resolved by calling Mallinckrodt Technical Services or your local Mallinckrodt representative.

Table 5-1: Problem Categories

Problem Area	Refer to Paragraph
1. Power • No power-up on AC and/or DC • Fails power-on self-test • Powers down without apparent cause	5.6.1
2. Buttons • Monitor does not respond properly to buttons	5.6.2
3. Display/Alarms • Displays do not respond properly • Alarms or other tones do not sound properly or are generated without apparent cause	5.6.3
4. Operational Performance • Displays appear to be operational, but monitor shows no readings • Suspect readings	5.6.4
5. Data Port • NPB-290 and PC not communicating properly • Nurse Call not functioning properly	5.6.5

All of the categories in Table 5-1 are discussed in the following paragraphs.

5.6.1 Power

Power problems are related to AC and/or DC. Table 5-2 lists recommended solutions to power problems.

Table 5-2: Power Problems

Condition	Recommended Action
1. BATTERY LOW indicator lights steadily while NPB-290 is connected to AC and battery is fully charged.	1. Ensure that the NPB-290 is plugged into an operational AC outlet and the AC indicator is on. 2. Check the fuses. The Power Entry Module contains the fuses as indicated in paragraph 6.3 and Figure 6-1 of Section 6, *Disassembly Guide*. Replace fuses if necessary. 3. Open the monitor as described in paragraph 6.4. Verify the power supply's output to the battery while on AC power. Disconnect the battery leads from the battery and connect a digital voltmeter (DVM) to the leads from the power supply. The voltage measured should be 6.80 volts DC ± 0.15 volts DC. Connect the negative lead to the battery, connect the DVM in series between the positive leads of the battery and the power supply. The current measured should be 400 mA ± 80 mA. Replace power supply if above values are not met (refer to paragraph 6.8). 4. Check the cable connection from the bottom enclosure to the User Interface PCB, as instructed in paragraph 6.11 of Section 6, *Disassembly Guide*. If the connection is good, replace the User Interface PCB.
2. The NPB-290 does not operate when disconnected from AC power.	1. The battery may be discharged. To recharge the battery, refer to paragraph 3.3.1, *Battery Charge*. The monitor may be used with a less than fully charged battery but with a corresponding decrease in operating time. 2. If the battery fails to hold a charge, replace the battery as indicated in paragraph 6.6.
3. BATTERY LOW indicator on during DC operation and an alarm is sounding.	There are 15 minutes or less of usable charge left on the NPB-290 battery before the instrument shuts off. At this point, if possible, cease use of the NPB-290 on battery power, connect it to an AC source, and allow it to recharge. The full recharge takes 14 hours. The NPB-290 may continue to be used while it is recharging.
4. Battery does not charge.	1. Replace battery if more than 2 years old. 2. Perform step 3 of the recommended action for condition 1 above.

5.6.2 Buttons

Table 5-3 lists symptoms of problems relating to nonresponsive buttons and recommended actions. If the action requires replacement of a PCB, refer to Section 6, *Disassembly Guide*.

Table 5-3: Button Problems

Symptoms	Recommended Action
1. The NPB-290 responds to some, but not all, buttons.	1. Replace Top Housing assembly. Refer to paragraph 6.4. 2. If the buttons still do not work, replace the User Interface PCB. Refer to paragraph 6.11.
2. The NPB-290 turns on but does not respond to any of the buttons.	1. Check the connection between the membrane panel and J5 of the User Interface PCB. Refer to paragraph 6.10. 2. Replace Top Housing assembly. Refer to paragraph 6.4. 3. If the buttons still do not work, replace the User Interface PCB. Refer to paragraph 6.11.

5.6.3 Display/Alarms

Table 5-4 lists symptoms of problems relating to nonfunctioning displays, audible tones or alarms, and recommended actions. If the action requires replacement of a PCB or module, refer to Section 6, *Disassembly Guide*.

Table 5-4: Display/Alarms Problems

Symptoms	Recommended Action
1. Display values are missing or erratic.	1. Try another sensor or relocate the sensor to a different site. 2. If the sensor is connected, replace the sensor connector assembly. 3. If the condition persists, replace the sensor extension cable. 4. If the condition still persists, replace the User Interface PCB. Refer to paragraph 6.11.
2. Not all display segments light during POST.	1. Check the connection between the User Interface PCB and the Display PCB. See Figures 6-8 and 6-9. 2. If the condition does not change, replace the Display PCB. Refer to paragraph 6.10. 3. If the condition still persists, replace the User Interface PCB. Refer to paragraph 6.11.
3. All Front Panel LED indicators do not light during POST.	1. Check the connection between the membrane panel and J5 of the User Interface PCB. See Figures 6-8 and 6-9. 2. Replace Top Housing assembly. Refer to paragraph 6.4.
4. Alarm sounds for no apparent reason.	1. Moisture or spilled liquids can cause an alarm to sound. Allow the monitor to dry thoroughly before use. 2. If the condition persists, replace the User Interface PCB. Refer to paragraph 6.11.
5. Display is flashing but there is no audible alarm.	1. Verify that alarm silence has not been activated. 2. Check speaker connection to UIF PCB. Refer to paragraph 6.12. 3. Replace the speaker. Refer to paragraph 6.12. 4. If the condition persists, replace the User Interface PCB. Refer to paragraph 6.11.
6. An alarm condition exists but no alarm (audible or visual) is indicated.	Replace the User Interface PCB. Refer to paragraph 6.11.

5.6.4 Operational Performance

Table 5-5 lists symptoms of problems relating to operational performance (no error codes displayed) and recommended actions. If the action requires replacement of a PCB or module, refer to Section 6, *Disassembly Guide*.

Table 5-5: Operational Performance Problems

Symptoms	Recommended Action
1. The Pulse Amplitude indicator seems to indicate a pulse, but the digital displays show zeroes.	1. The sensor may be damaged; replace it. 2. If the condition persists, replace the User Interface PCB. Refer to paragraph 6.11.
2. SpO_2 or pulse rate values change rapidly; Pulse Amplitude indicator is erratic.	1. The sensor may be damp or may have been reused too many times. Replace it. 2. An electrosurgical unit (ESU) may be interfering with performance: _ Move the NPB-290 and its cables and sensors as far from the ESU as possible. _ Plug the NPB-290 and the ESU into different AC circuits. _ Move the ESU ground pad as close to the surgical site as possible and as far away from the sensor as possible. 3. Verify performance with the procedures detailed in Section 3. 4. If the condition persists, replace the User Interface PCB. Refer to paragraph 6.11.

5.6.5 Data Port

Table 5-6 lists symptoms of problems relating to the data port and recommended actions. If the action requires replacement of the PCB, refer to Section 6, *Disassembly Guide*.

Table 5-6: Data Port Problems

Symptoms	Recommended Action
1. No printout is being received.	1. The unit is running on battery power. Connect to an AC source. If the AC indicator is not on, Refer to paragraph 5.6.1. 2. The monitor's baud rate does not match the printer. Change the baud rate of the monitor, following instructions in Operator's manual. 3. Check connections between data port and printer. Refer to paragraph 10.3. 4. If the condition still persists, replace the User Interface PCB. Refer to paragraph 6.11.
2. The Nurse Call function (RS232 level) is not working.	1. The unit is running on battery power. Connect to an AC source. If the AC indicator is not on, Refer to paragraph 5.6.1. 2. Verify connections are made between pins 5 or 10 (GND) and 11 (Nurse Call) of the data port. Refer to paragraph 10.5. 3. Verify output voltage between ground pin 5 or 10 and pin 11 is -5 to -12 VOLTS DC (no alarm) and +5 to +12 VOLTS DC (during alarm). Refer to paragraph 3.3.3.1.5. 4. If the condition still persists, replace the User Interface PCB. Refer to paragraph 6.11.
3. The Nurse Call function (relay contacts) is not working.	1. Verify voltage and current do not exceed values stated in Table 10-4. 2. Replace User Interface PCB. Refer to paragraph 6.11.
4. RS-422 not working.	1. Verify the cable is constructed following procedures outlined in paragraph 10.3. 2. Replace User Interface PCB. Refer to paragraph 6.11.
5. Analog data inaccurate.	1. Verify NPB-290 is operating on AC power. Refer to paragraph 3.3.2.1. 2. Verify the recorder is calibrated to the NPB-290. Refer to recorder Operator's manual. 3. Verify the analog output values by performing the test outlined in paragraph 3.3.3.1.6. 4. Replace User Interface PCB. Refer to paragraph 6.11.

5.7 ERROR CODES

An error code will be displayed when the NPB-290 detects a non-correctable failure. When this occurs, the unit will stop monitoring, sound a low priority alarm that cannot be silenced, clear patient data from the display, and display an error code. Error codes will be displayed with EEE in the saturation display and the number of the code in the pulse rate display, i.e., EEE 1. Table 5-7 provides a complete list of error codes and possible solutions. Cycling the power will clear the code and allow the instrument to function normally if no other errors are detected.

Table 5-7: Error Codes

Code	Meaning	Possible Solutions
1	POST failure	Replace User Interface PCB. Refer to paragraph 6.11.
4	Battery dead	1. Check the voltage selector switch. Refer to the N-290 Operator's manual. 2. Charge battery for 14 hours. Refer to paragraph 3.3.1. 3. Leads of battery reversed. Refer to paragraph 6.6. 4. Replace battery. Refer to paragraph 6.6.
5	Too many microprocessor resets within a period of time	1. Cycle power to clear error 2. Replace User Interface PCB. Refer to paragraph 6.11. 3. Replace Power Supply PCB. Refer to paragraph 6.8.
6	Boot CRC error	1. Cycle power to clear error 2. Replace User Interface PCB. Refer to paragraph 6.11.
7	Error on User Interface PCB	1. Cycle power to clear error. 2. Check voltage selector switch for proper setting. 3. Replace User Interface PCB. Refer to paragraph 6.11.
11	Flash ROM corruption	1. Cycle power to clear error 2. Replace User Interface PCB. Refer to paragraph 6.11.
52	Institutional default values lost and reset to factory default values	1. Cycle power to clear error 2. Replace User Interface PCB. Refer to paragraph 6.11.
76	Error accessing EEPROM	1. Cycle power to clear error 2. Replace User Interface PCB. Refer to paragraph 6.11.
80	Institutional default values lost and reset to factory default values	1. Cycle power to clear error 2. Replace User Interface PCB. Refer to paragraph 6.11.

Table 5-7: Error Codes

Code	Meaning	Possible Solutions
82	Time clock lost	1. Reset time clock 2. Battery power lost, check the battery. Refer to paragraph 3.3.3.1.7. 3. Replace the Power Supply. Refer to paragraph 6.8.
84	Internal communications error	1. Cycle power to clear error 2. Replace User Interface PCB. Refer to paragraph 6.11.

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SECTION 6: DISASSEMBLY GUIDE

6.1 Introduction
6.2 Prior to Disassembly
6.3 Fuse Replacement
6.4 Monitor Disassembly
6.5 Monitor Reassembly
6.6 Battery Replacement
6.7 Power Entry Module (PEM) Removal/Replacement
6.8 Power Supply Removal/Replacement
6.9 Cooling Fan Removal/Replacement
6.10 Display PCB Removal/Replacement
6.11 User Interface PCB Removal/Replacement
6.12 Alarm Speaker Removal/Replacement

6.1 INTRODUCTION

The NPB-290 can be disassembled down to all major component parts, including:

- PCBs
- Battery
- Top and Bottom Housing
- Speaker
- Power Entry Module (PEM)

The following tools are required:

- Phillips-head screwdriver #1
- 10 mm open-end wrench
- Needle-nose pliers
- Torque wrench, 10 inch-pounds (1.13 Newton-meters)
- Wire Cutters
- Flat blade screwdriver

WARNING: Before attempting to open or disassemble the NPB-290, disconnect the power cord from the NPB-290.

Caution: Observe ESD (electrostatic discharge) precautions when working within the unit.

Note: Some spare parts have a business reply card attached. When you receive these spare parts, please fill out and return the card.

6.2 PRIOR TO DISASSEMBLY

1. Turn the NPB-290 off by pressing the Power On/Off button.
2. Disconnect the monitor from the AC power source.

6.3 FUSE REPLACEMENT

1. Complete the procedure in paragraph 6.2.
2. Disconnect the power cord from the back of the monitor.
3. Use a flat blade screwdriver to remove the fuse drawer from the Power Entry Module. Press down on the tab in the center of the fuse drawer with the screwdriver until a click is heard. Pull the drawer out as shown in Figure 6-1.

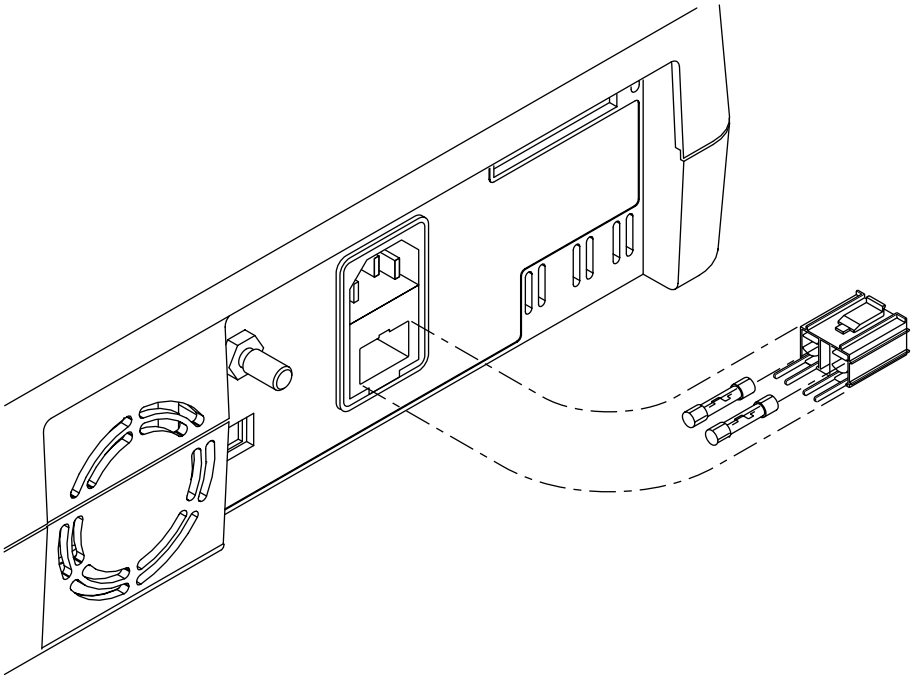

Figure 6-1: Fuse Removal

4. Put new, 5 x 20 mm, slow blow, 0.5-amp, 250-volt fuses in the drawer and reinsert the drawer in the power module.

6.4 MONITOR DISASSEMBLY

Caution: Observe ESD (electrostatic discharge) precautions when disassembling and reassembling the NPB-290 and when handling any of the components of the NPB-290.

1. Set the NPB-290 upside down, as shown in Figure 6-2.

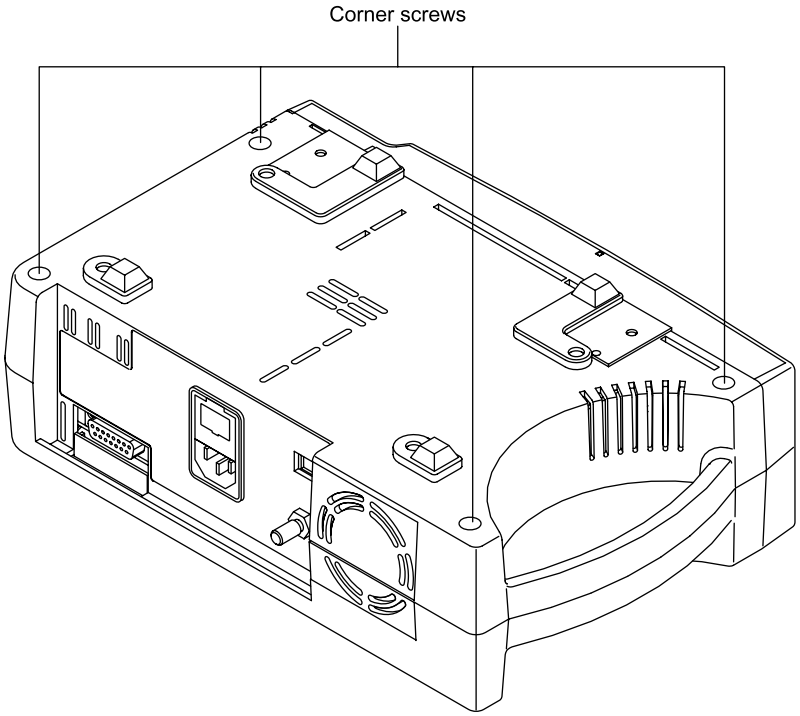

Figure 6-2: NPB-290 Corner Screws

2. Remove the four corner screws.
3. Turn the unit upright.
4. Separate the top case from the bottom case of the monitor, being careful not to stress the wire harnesses between the cases.
5. Place the two halves of the monitor on the table as shown in Figure 6-3.
6. Disconnect the power supply from J6 on the User Interface PCB.

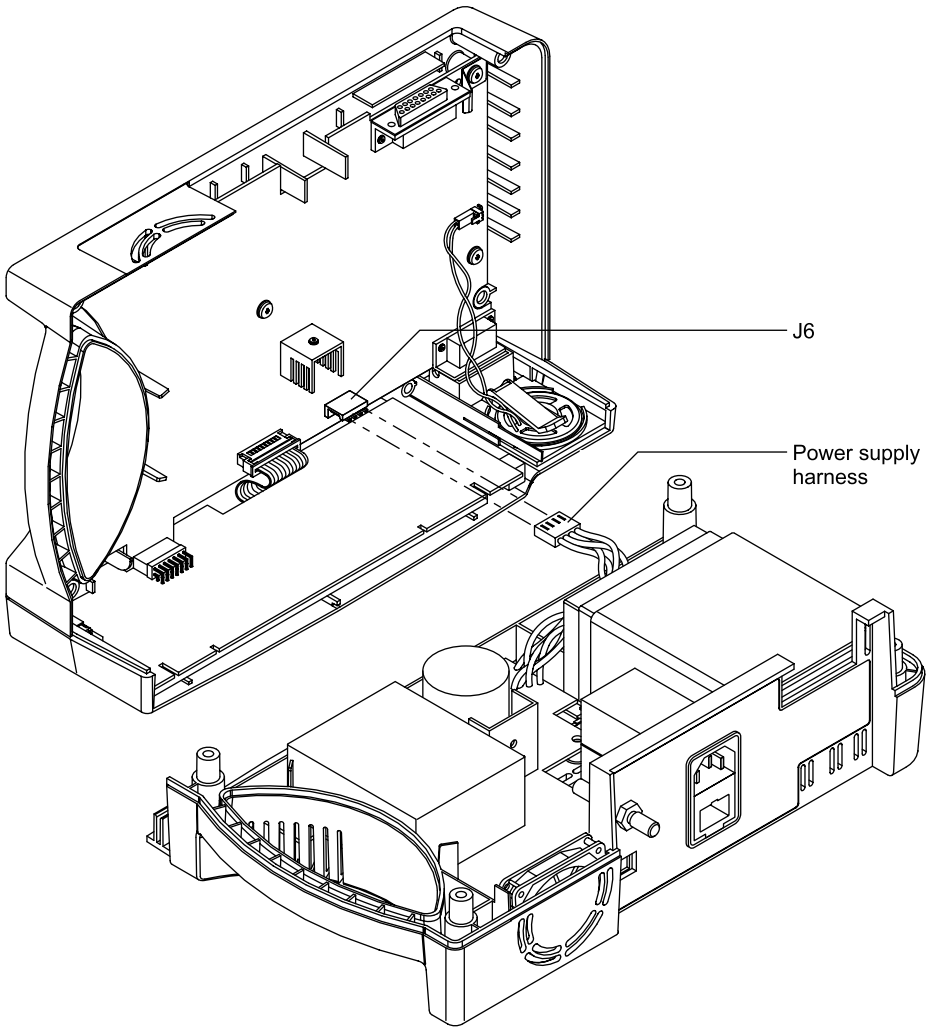

Figure 6-3: Separating Case Halves

6.5 MONITOR REASSEMBLY

1. Place the two halves of the monitor on the table as shown in Figure 6-3.
2. Connect the power supply to J6 on the User Interface PCB.
3. Place the top case over the bottom case.
4. Align the four outside screw posts.
5. Close the monitor.

Caution: When reassembling the NPB-290, hand-tighten the screws that hold the cases together to a maximum of 10 inch-pounds. Over-tightening could strip out the screw holes in the top case, rendering them unusable.

6. Install the four corner screws.

6.6 BATTERY REPLACEMENT

Removal

1. Follow procedure in paragraphs 6.2 and 6.4.
2. Remove the two screws from the battery bracket as shown in Figure 6-4.
3. Lift the battery out of the bottom case.
4. Use needle-nose pliers to disconnect the leads from the battery.

Note: The lead-acid battery is recyclable. Do not dispose of the battery by placing it in the regular trash. Dispose of properly according to state, local, or other applicable regulations, or contact Mallinckrodt Technical Services to return for disposal.

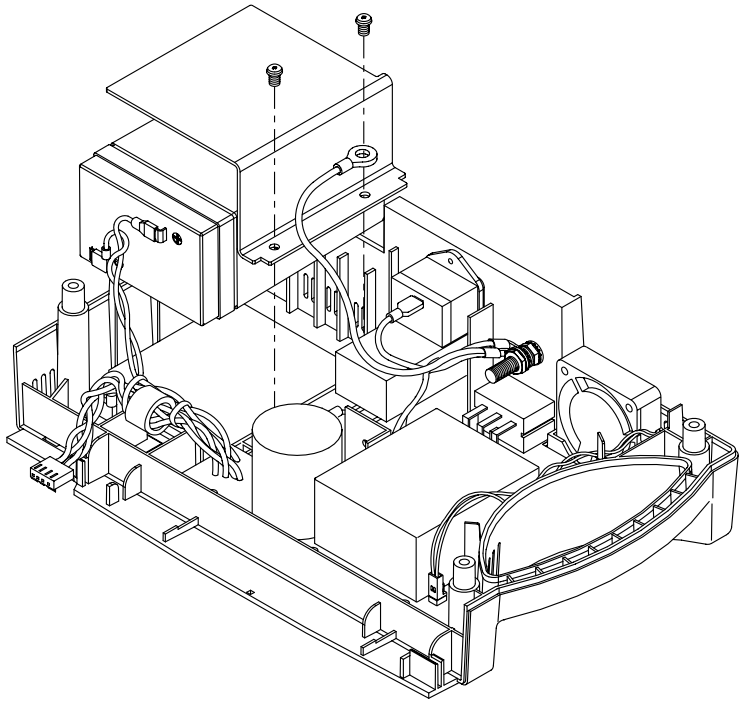

Figure 6-4: Battery Removal

Replacement

5. Connect the leads to the battery.
   - Red wire connects to the positive terminal.
   - Black wire goes to the negative.
6. Insert the new battery into the bottom case with the negative terminal towards the bottom of the monitor.
7. Install the bracket and grounding lead with the two screws.
8. Complete the procedure in paragraph 6.5.
9. Turn the monitor on and verify proper operation.

6.7 POWER ENTRY MODULE (PEM) REMOVAL/REPLACEMENT

Removal

1. Complete the procedure in paragraphs 6.2 and 6.4.
2. While pushing the top of the PEM in from the outside of the case, gently push the case to the outside and lift up on the PEM.
3. Use needle-nose pliers to disconnect the leads from the PEM (see Figure 6-5).

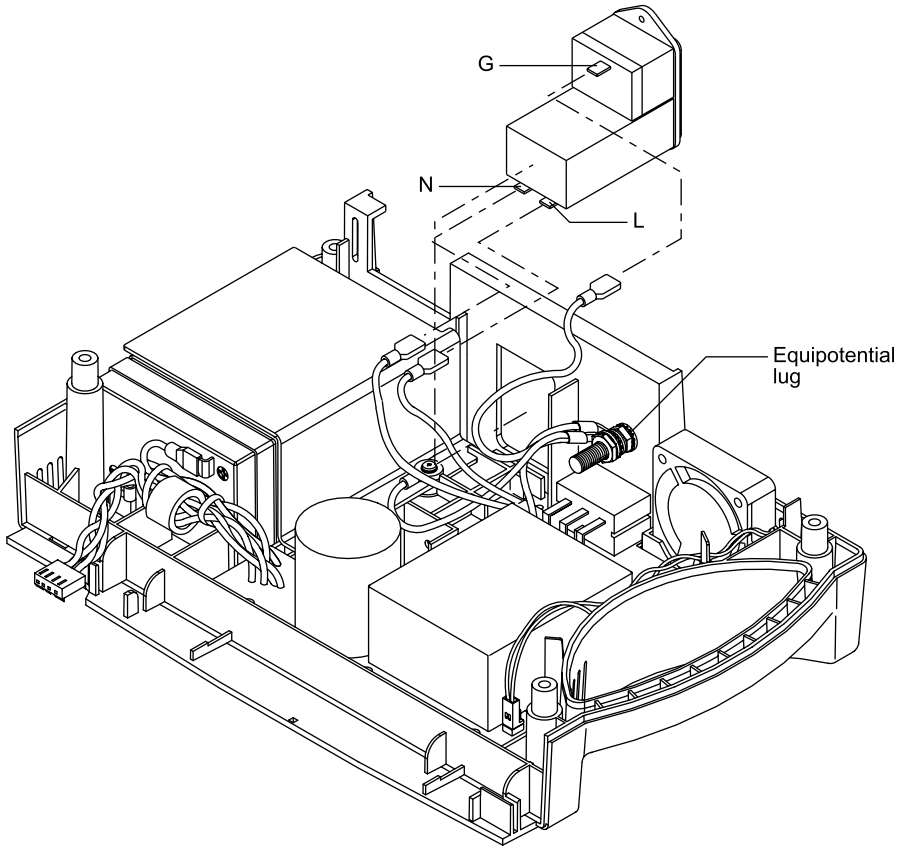

Figure 6-5: Power Entry Module

Replacement

4. Refer to Table 6-1 and connect the leads to the PEM.
5. Install the PEM in the bottom case with the fuse drawer facing down. A tab in the bottom case holds the PEM in place. Insert the bottom wing of the PEM between the tab and the internal edge of the sidewall in the bottom case. Push the PEM down and towards the outside of the monitor until it clicks into place.
6. Position the ground line from the PEM so that it does not come into contact with components on the Power Supply PCB.
7. Complete the procedure in paragraph 6.5.

6.8 POWER SUPPLY REMOVAL/REPLACEMENT

Removal

1. Complete the procedure described in paragraphs 6.2 and 6.4.
2. Disconnect the leads from the battery.
3. Follow the procedure in paragraph 6.7, steps 2 and 3.
4. Use a 10-mm wrench to disconnect the power supply ground lead from the equipotential lug (Figure 6-5).
5. Disconnect the cooling fan harness from J1 of the power supply (Figure 6-7).
6. Remove the seven screws shown in Figure 6-6.
7. Lift the power supply out of the bottom case.

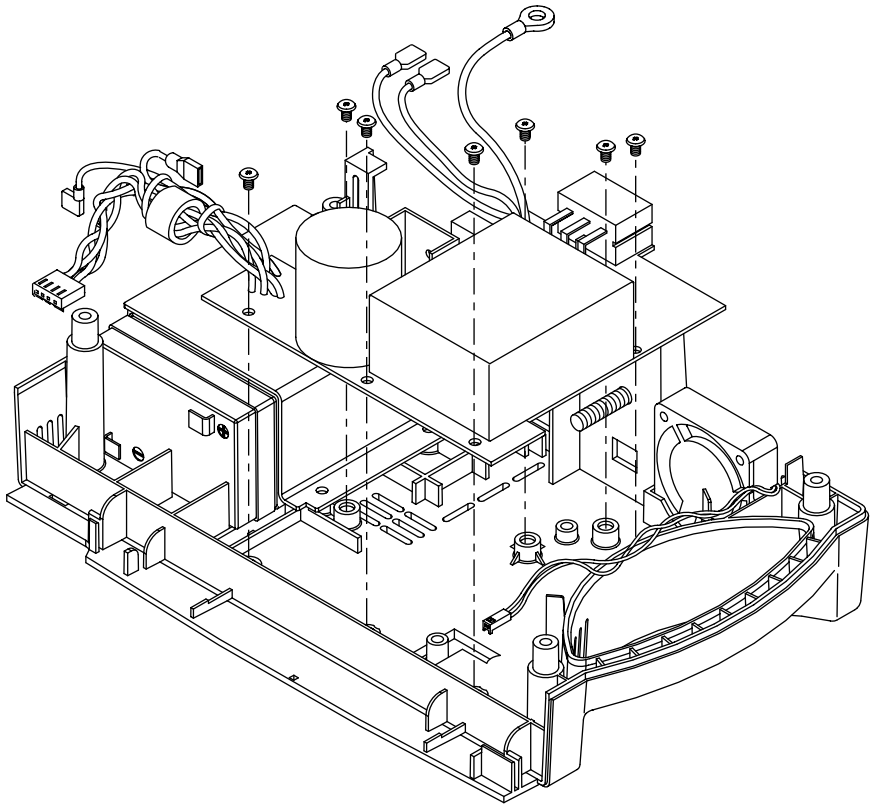

Figure 6-6: Power Supply

Replacement

8. Connect the AC leads W1, W2, and W3 to the PEM following the instructions in Table 6-1.

Table 6-1: Power Supply Leads Connections

Power Supply Lead	Wire Color or Label	Connects To
W1	Green & Yellow "G"	Equipotential Lug
W2	Brown/Labeled "L"	"L" on the Power Entry Module
W3	Blue/Labeled "N"	"N" on the Power Entry Module
W4	Red	Positive Battery Terminal
W5	Black	Negative Battery Terminal

9. Place the power supply in the bottom case.

Caution: When installing the Power Supply, tighten the seven screws to a maximum of 10 inch-pounds. Over-tightening could strip out the inserts in the bottom case, rendering them unusable.

10. Install the seven screws in the power supply and tighten.
11. Connect the cooling fan harness to J1 of the power supply.
12. Use a 10-mm open-end wrench to connect the power supply ground lead to the equipotential lug. Tighten to 12 inch-pounds.
13. Follow the procedure in paragraph 6.7, steps 5 and 6.
14. Verify the ground wire to the PEM is positioned so that it does not come into contact with components on the Power Supply PCB.
15. Reconnect W4 and W5 to the battery by following the instructions in Table 6-1.
16. Complete the procedure in paragraph 6.5.

6.9 COOLING FAN REMOVAL/REPLACEMENT

Removal

1. Complete procedures described in 6.2 and 6.4.
2. Lift the cooling fan from the slots in the bottom case (see Figure 6-7).
3. Disconnect the fan wire harness from J1 on the power supply PCB.

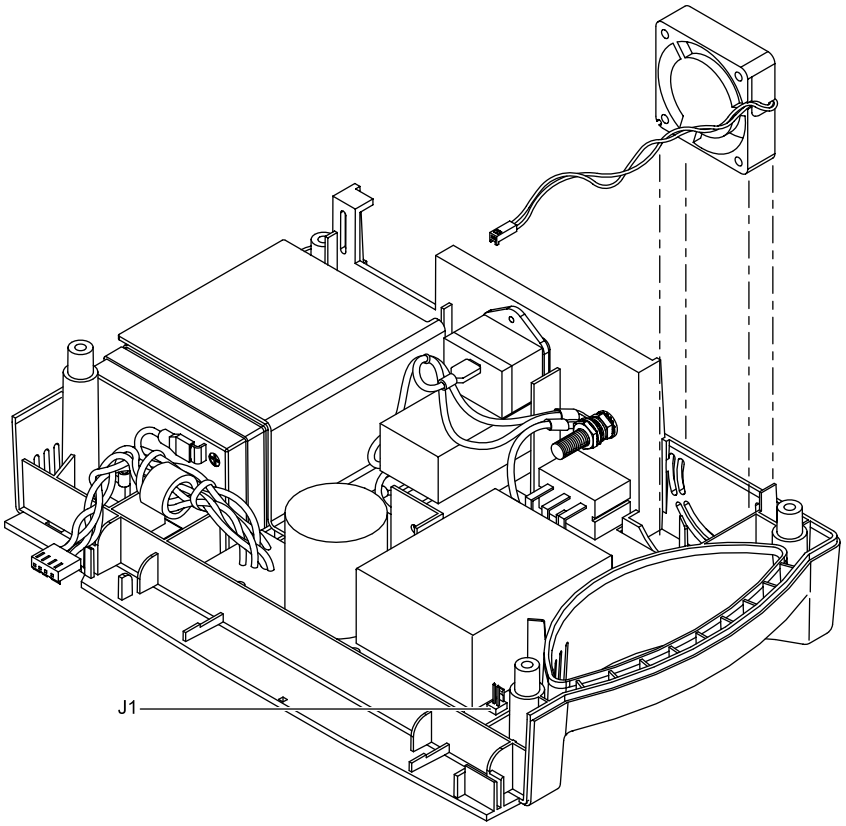

Figure 6-7: Cooling Fan

Replacement

4. Connect the cooling fan wire harness to J1 on the power supply PCB.
5. Insert the cooling fan into the slots in the bottom case with the padded sides on the top and bottom and the fan's harness to the handle side of the case.
6. Complete procedure 6.5.

6.10 DISPLAY PCB REMOVAL/REPLACEMENT

Removal

1. Complete the procedure described in paragraphs 6.2 and 6.4.

Caution: Care must be taken when removing the Display PCB from the top case to avoid scratching the lens or LED modules.

2. Gently pull the top of the Display PCB towards the inside of the instrument and lift the Display PCB up to remove it from the top case (Figure 6-8).

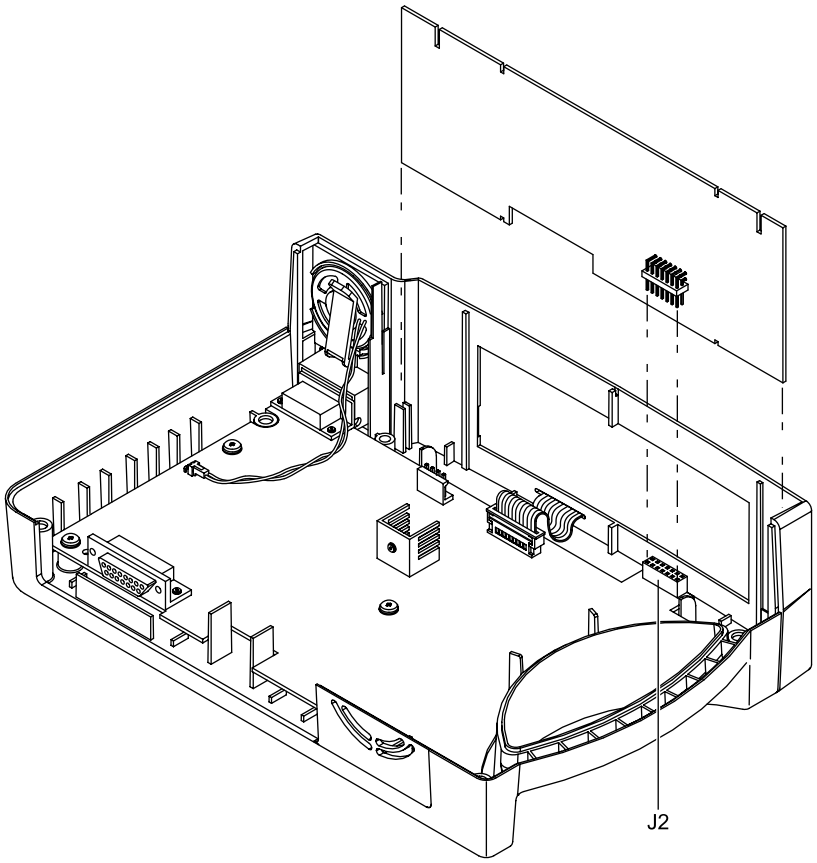

Figure 6-8: Display PCB

Replacement

Caution: Care must be taken when installing the Display PCB into the top case to avoid scratching the lens or LED modules.

3. Tilt the top of the Display PCB towards the inside of the instrument and gently slide the Display PCB into the grooves in the top case. Be careful to align the male pins from the Display PCB to connector J2 on the User Interface PCB.

4. Complete the procedure described in paragraph 6.5.

6.11 USER INTERFACE PCB REMOVAL/REPLACEMENT

Removal

1. Complete the procedure described in paragraphs 6.2 and 6.4.
2. Follow step 2 of paragraph 6.10 (Figure 6-8).
3. Disconnect the keypad ribbon cable from the ZIF connector, J8, on the User Interface PCB (Figure 6-9). Lift up on the outer shell until it clicks, then remove the ribbon cable from the connector.
4. Disconnect the speaker cable from J13 of the User Interface PCB.
5. Remove the five screws in the User Interface PCB.

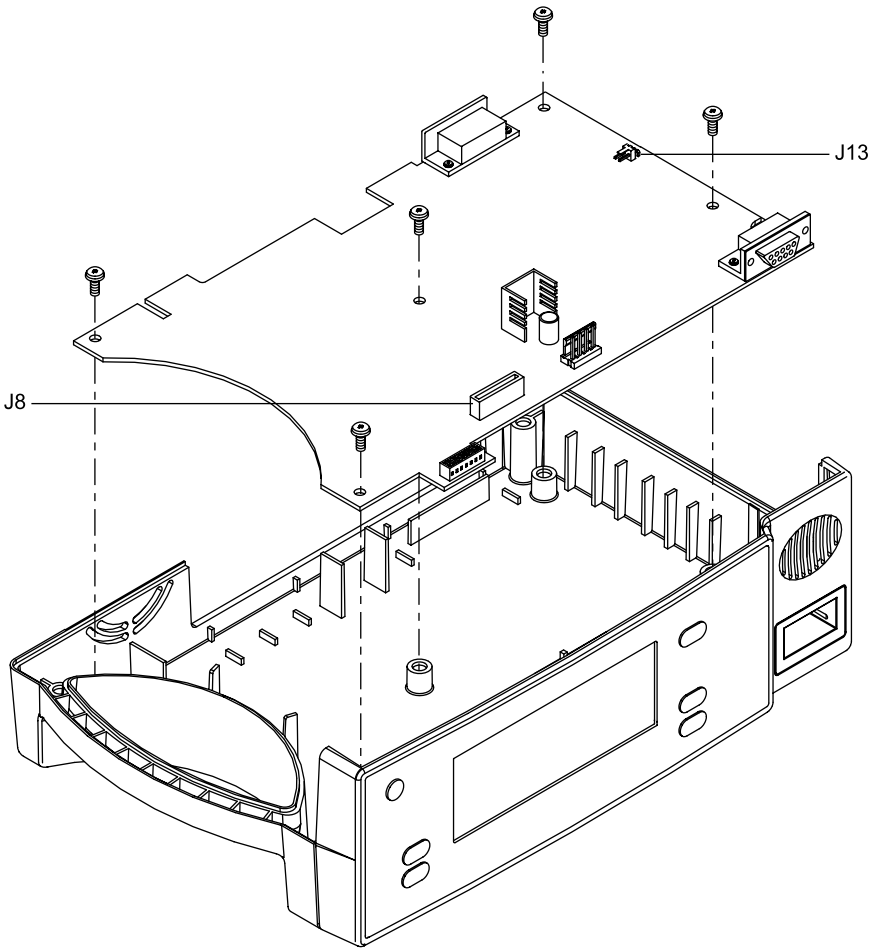

Figure 6-9: User Interface PCB

6. Remove the User Interface PCB from the top case.

Replacement

Caution: When installing the User Interface PCB, hand-tighten the five screws to a maximum of 10 inch-pounds. Overtightening could strip out the inserts in the top case, rendering them unusable.

7. Place the User Interface PCB in the top case.
8. Install the five screws in the User Interface PCB.
9. Lift up on the outer shell of J8 on the User Interface PCB until it clicks.
10. Insert the keypad ribbon cable into J8 of the User Interface PCB.
11. Slide the outer shell of J8 down until it clicks.
12. Connect the speaker cable to J13 of the User Interface PCB.
13. Follow step 3 of paragraph 6.10.
14. Complete the procedure in paragraph 6.5.

6.12 ALARM SPEAKER REMOVAL/REPLACEMENT

Removal

1. Complete the procedure described in paragraphs 6.2 and 6.4.
2. Disconnect the speaker wire harness for J13 on the User Interface PCB (see Figure 6-10).
3. Pull the speaker holding clip towards the center of the monitor and lift the speaker from the top housing.

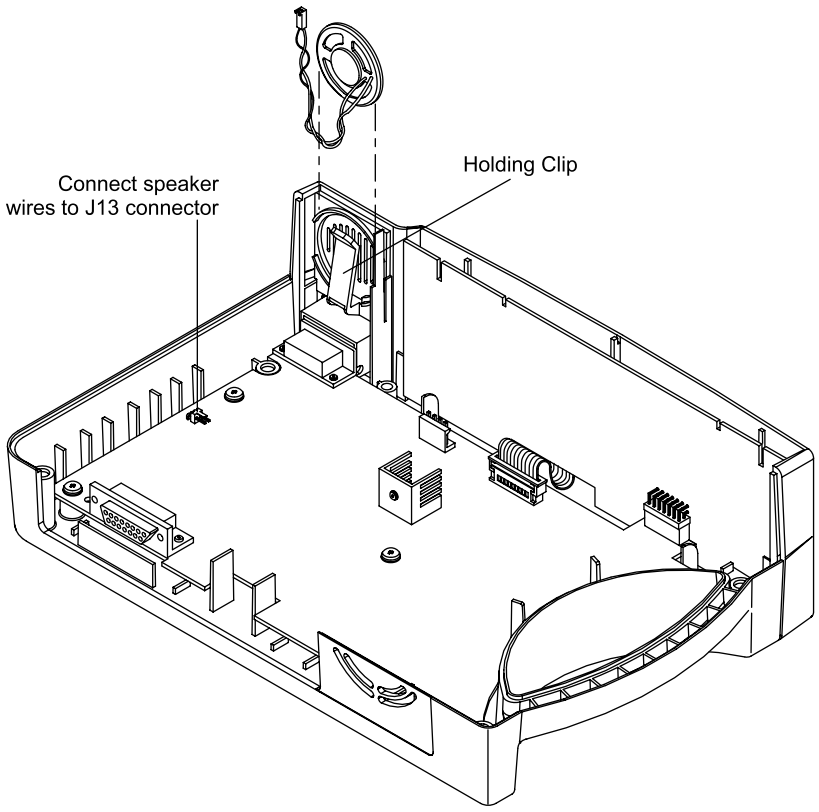

Figure 6-10: Alarm Speaker

Replacement

4. Slide the speaker into the plastic holding clip provided in the top housing.
5. Connect the speaker wire harness to J13 on the User Interface PCB.
6. Complete the procedure described in paragraph 6.5.

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SECTION 7: SPARE PARTS

7.1 INTRODUCTION

Spare parts, along with part numbers, are shown in Table 7-1. Figure 7-1 shows the NPB-290 expanded view with item numbers relating to the spare parts list.

Table 7-1: Parts List

Item	Description	Part No.
1	Top Case Assembly (Membrane Panel Included)	048497
2	Fuse Drawer	691500
3	Fuses	691032
4	Power Entry Module	691499
5	Cooling Fan	035469
6	Power Supply	035800
7	Display PCB (Printed Circuit Card)	035347
8	Battery	640119
9	Battery Bracket	035307
10	User Interface PCB	035351
	Alarm Speaker (not shown)	033494
	Rubber Feet (not shown)	4-003818-00
	Power Cord (not shown)	U.S. 071505 International 901862 U.K. 901863
	Tilt Stand (not shown)	891340
	GCX Mounting Kit (not shown)	035434

Note: Some spare parts have a business reply card attached. When you receive these spare parts, please fill out and return the card.

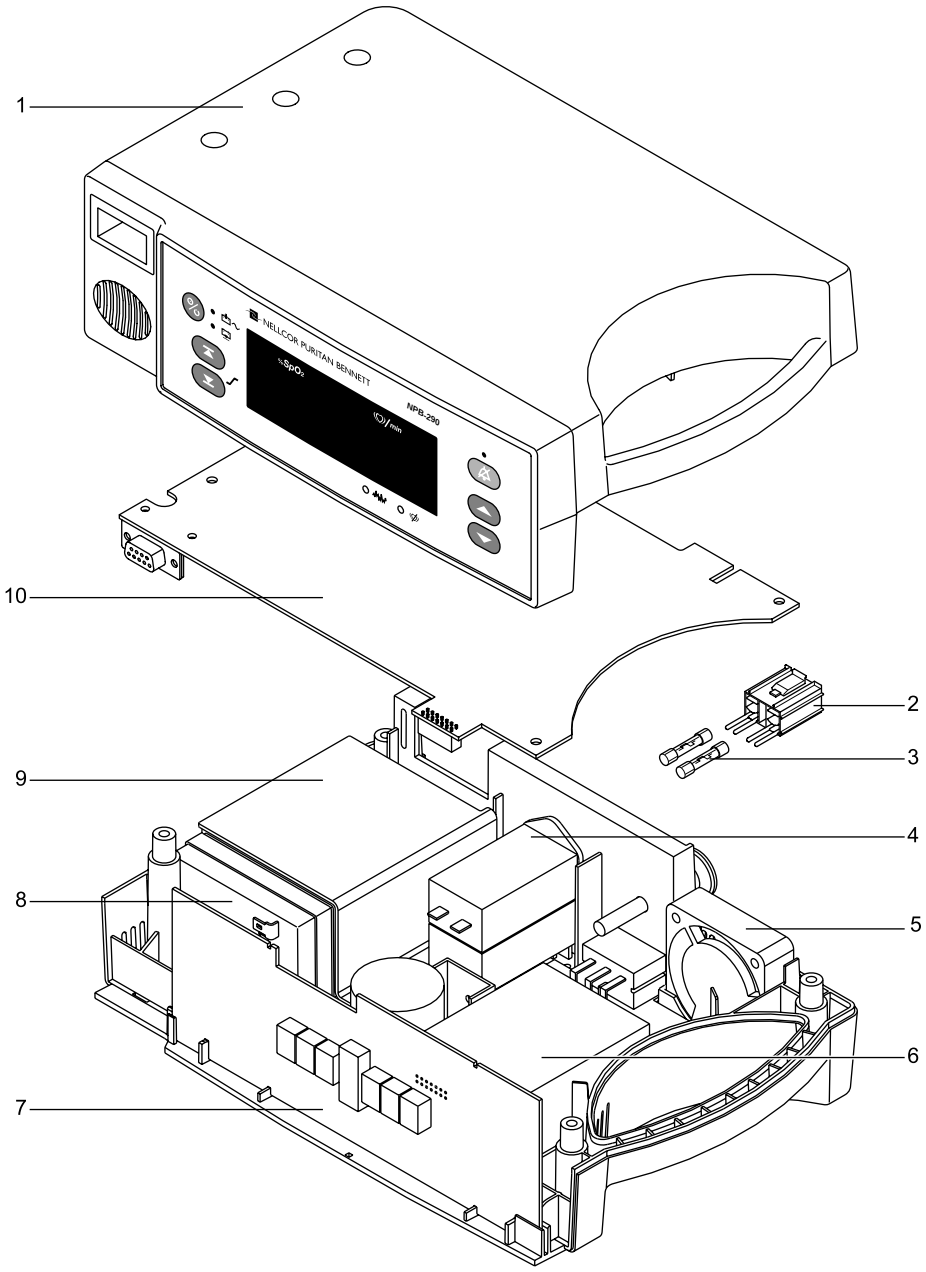

Figure 7-1: NPB-290 Exploded View

SECTION 8: PACKING FOR SHIPMENT

8.1 General Instructions
8.2 Repacking in Original Carton
8.3 Repacking in a Different Carton

To ship the monitor for any reason, follow the instructions in this section.

8.1 GENERAL INSTRUCTIONS

Pack the monitor carefully. Failure to follow the instructions in this section may result in loss or damage not covered by any applicable Mallinckrodt warranty. If the original shipping carton is not available, use another suitable carton. North American customers may call Mallinckrodt Technical Services Department to obtain a shipping carton.

Before shipping the NPB-290, contact Mallinckrodt Technical Services Department for a returned goods authorization (RGA) number. Mark the shipping carton and any shipping documents with the RGA number. European customers not using RGA numbers should return the product with a detailed, written description of the problem.

Return the NPB-290 by any shipping method that provides proof of delivery.

8.2 REPACKING IN ORIGINAL CARTON

If available, use the original carton and packing materials. Pack the monitor as follows:

1. Place the monitor in a plastic bag (not shown in Figure 8-1) and, if necessary, accessory items in original packaging.
2. Place in shipping carton and seal carton with packing tape.
3. Label carton with shipping address, return address, and RGA number.

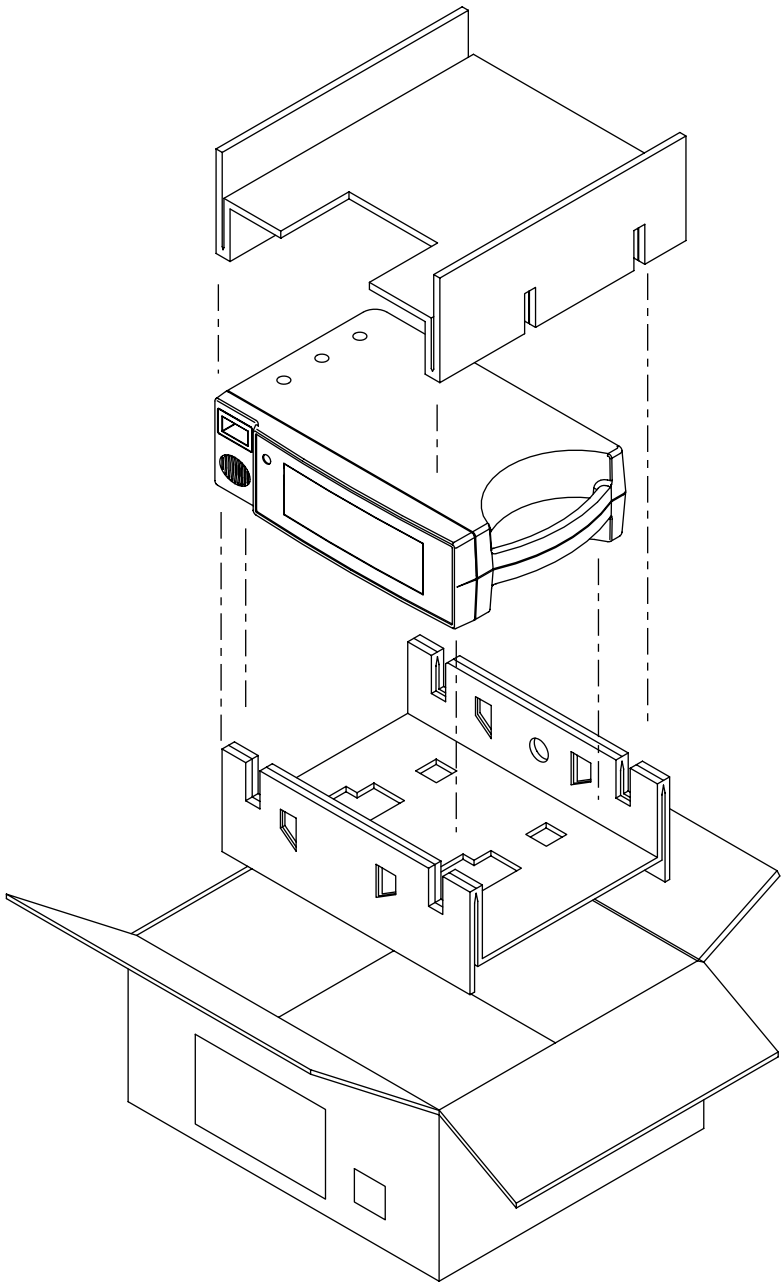

Figure 8-1: Repacking the NPB-290

8.3 REPACKING IN A DIFFERENT CARTON

If the original carton is not available, use the following procedure to pack the NPB-290:

1. Place the monitor in a plastic bag.
2. Locate a corrugated cardboard shipping carton with at least 200 pounds per square inch (psi) bursting strength.
3. Fill the bottom of the carton with at least 2 inches of packing material.
4. Place the bagged unit on the layer of packing material and fill the box completely with packing material.
5. Seal the carton with packing tape.
6. Label the carton with the shipping address, return address, and RGA number.

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SECTION 9: SPECIFICATIONS

9.1 General
9.2 Electrical
9.3 Physical Characteristics
9.4 Environmental
9.5 Alarms
9.6 Factory Default Settings
9.7 Performance

9.1 GENERAL

Designed to meet safety requirements of:

UL 2601-1 CSA-C22.2 No. 601-1-M90, IEC 601-1 (Class I, type BF), ISO 9919, EMC per EN 60601-1-2.

9.2 ELECTRICAL

Protection Class	Class I: per I.E.C. 601-1, clause 2.2.4
Degree of Protection	Type BF: per I.E.C. 601-1, clause 2.1.25
Mode of Operation	Continuous
Battery	
Type:	Rechargeable, sealed lead-acid, internal
Operating time:	8 hours minimum on new, fully charged battery and no active alarms
Recharge period:	14 hours for full charge in standby 18 hours while in use
Fuses	2 each 5 x 20 mm Slow Blow 0.5 amp, 250 volts
AC Power	
Selectable by switch	100-120 volts AC, 50/60 Hz or 200-240 volts AC, 50/60 Hz

9.3 PHYSICAL CHARACTERISTICS

Dimensions	3.3 in. H x 10.4 in. W x 6.8 in. D 8.4 cm H x 26.4 cm W x 17.3 cm D
Weight	5.5 lb, 2.5 kg

9.4 ENVIRONMENTAL

Operating Temperature	5° C to 40° C (+41° F to +104° F)
Storage Temperature	
Boxed	-20° C to +70° C (-4° F to +158° F)
Unboxed	-20° C to +60° C (-4° F to +140° F)
Operating Atmospheric Pressure	700 hPa to 1060 hPa (20.65 in Hg to 31.27 in Hg)
Relative Humidity	15% RH to 95% RH, noncondensing

9.5 ALARMS

Alarm Limit Range

% Saturation	20–100%
Pulse Rate	30–250 bpm

9.6 FACTORY DEFAULT SETTINGS

Table 9-1: Default Settings

Parameter	Default Setting
Alarm Silence Behavior	Off with a reminder
Audible Alarm Silence Duration	60 seconds
Audible Alarm Volume	Level 5
Baud Rate	9600
Communication Protocol	Serial output mode ASCII
High Pulse Rate Alarm	170 bpm
Low Pulse Rate Alarm	40 bpm
Pulse Beep Volume	Level 4
SpO_2 High Alarm	100%
SpO_2 Low Alarm	85%

9.7 PERFORMANCE

Measurement Range

SpO_2:	0–100%
Pulse/Heart Rate:	20–250 bpm

Accuracy

SpO_2

Adult:	70–100% ± 2 digits 0–69% unspecified
Neonate:	70–100% ± 3 digits 0–69% unspecified

Accuracies are expressed as plus or minus "X" digits (saturation percentage points) between saturations of 70-100%. This variation equals plus or minus one standard deviation (1SD), which encompasses 68% of the population. All accuracy specifications are based on testing the subject monitor on healthy adult volunteers in induced hypoxia studies across the specified range. Adult accuracy is determined with *Oxisensor II* D-25 sensors. Accuracy for neonatal readings is determined with *Oxisensor II* N-25 sensors. In addition, the neonatal accuracy specification is adjusted to take into account the theoretical effect of fetal hemoglobin in neonatal blood on oximetry measurements.

Pulse Rate (optically derived) 20–250 bpm ± 3 bpm

Accuracies are expressed as plus or minus "X" bpm across the display range. This variation equals plus or minus 1 Standard Deviation, which encompasses 68% of the population.

SECTION 10: DATA PORT INTERFACE PROTOCOL

10.1 Introduction
10.2 Enabling the Data Port
10.3 Connecting to the Data Port
10.4 Real-Time Printout
10.5 Nurse Call
10.6 Analog Output
10.7 Interactive Mode

10.1 INTRODUCTION

The data port, located at the rear of the NPB-290, provides interfacing capabilities for:

- printing NPB-290 data
- displaying NPB-290 data on a computer
- sending NPB-290 data to the Nellcor Oxinet II System
- Nurse Call

10.2 ENABLING THE DATA PORT

The data port supports three communication protocols:

- Option 0 = real-time ASCII for printouts or displays
- Option 1 = communications with Nellcor Oxinet II system
- Option 2 = Mallinckrodt Technical Services use only

Menu item 4 is used to select baud rate. To access menu item 4:

- disconnect the sensor cable
- press both the Upper and Lower Alarm Limit buttons simultaneously for 3 seconds
- press the Upper Alarm Limit button until menu item 6 is displayed
- select baud rate by pressing Adjust Up or Adjust Down button (2400, 9600 [default], or 19200)

Menu item 5 allows the user to choose between the three communication protocols. To access menu item 5:

- disconnect the sensor cable
- press both the Upper Alarm Limit and the Lower Alarm Limit buttons simultaneously for 3 seconds
- press the Upper Alarm Limit button until menu item 5 is displayed
- select desired option by pressing the Adjust Up or Adjust Down button

Note: More information on using menu options is provided in Section 4.

10.3 CONNECTING TO THE DATA PORT

Data is transmitted in the RS-232 format (pins 2, 3, and 5) or RS-422 (pins 1, 4, 9, and 12). RS-232 data can be transmitted a maximum of 25 feet. The pin outs for the data port are listed in Table 10-1.

Table 10-1 Data Port Pin Outs

Pin	Signal
1	RXD+ (RS-422 positive input)
2	RXD_232 (RS-232 input)
3	TXD_232 (RS-232 output)
4	TXD+ (RS-422 positive output)
5	Signal Ground (isolated from earth ground)
6	AN_SpO2 (analog saturation output)
7	Normally Open, Dry Contacts, for Nurse Call (N.O. with no active alarm)
8	Normally Closed, Dry Contacts, for Nurse Call (N.C. with no active alarm)
9	RXD- (RS-422 negative input)
10	Signal Ground (isolated from earth ground)
11	Nurse Call (RS-232 level output {-3 to -10 volts DC with no active alarm} {+3 to +10 volts DC with active alarm})
12	TXD- (RS-422 negative output)
13	AN_PULSE (analog pulse rate output)
14	AN_PLETH (analog pleth wave output)
15	Nurse Call Common for Dry Contacts

Note: When the instrument is turned off, the contact at pin 7 closes and the contact at pin 8 opens.

The pin layouts are illustrated in Figure 10-1. The conductive shell is used as earth ground. An AMP connector is used to connect to the data port. Use AMP connector (AMP P/N 747538-1), ferrule (AMP P/N 1-747579-2) and compatible pins (AMP P/N 66570-2).

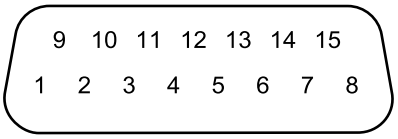

Figure 10-1: Data Port Pin Layout

When building an RS-422 cable, a resistor (120 Ω, 1/4 watt, 5%) must be added between pins 1 and 9 of the cable. The end of the cable with the resistor added must be plugged into the NPB-290. This resistor is not necessary for RS-232 cables.

The serial cable must have a braided shield providing 100% coverage such as Beldon cable (Beldon P/N 9616) or equivalent. Connectors at both ends of the serial cable must have the shield terminated to the full 360 degrees of the connector's metal shell. Do not create sharp bends in the cable, this may tear or break the shield.

10.4 REAL-TIME PRINTOUT

When a real-time printout is being transmitted, a new line of data is printed every 2 seconds. Every 25th line will be a Column Heading line. A Column Heading line will also be printed any time a value in the Column Heading line is changed. A real time printout is shown below in Figure 10-2.

Note: Printouts are available only if the instrument is running on AC power.

NPB-290	Version 1.0.0	CRC XXXX	SpO2 Limit:	30-100%	PR Limit: 100-180 bpm
TIME	%SpO2	PR (bpm)	PA	Status	
01-Jul-97 14:00:00	100	120	220		
01-Jul-97 14:00:02	100	124	220		
01-Jul-97 14:00:04	100	190	220		
01-Jul-97 14:00:06	100	190*	220	PH	
01-Jul-97 14:00:08	100	190*	220	PH	
01-Jul-97 14:00:10	100	190*	220	PH	
01-Jul-97 14:00:12	100	190*	220	PH	
01-Jul-97 14:00:14	100	190*	220	PH	
01-Jul-97 14:00:16	100	190*	220	PH LB	
01-Jul-97 14:00:18	100	190*	220	PH LB	
01-Jul-97 14:00:20	100	190*	220	PH LB	
01-Jul-97 14:00:22	- - -	- - -	- - -	SD	LB
01-Jul-97 14:00:24	- - -	- - -	- - -	SD	LB
01-Jul-97 14:00:26	- - -	- - -	- - -	SD	
01-Jul-97 14:00:28	- - -	- - -	- - -	SD	
01-Jul-97 14:00:30	- - -	- - -	- - -	SD	
01-Jul-97 14:00:32	- - -	- - -	- - -	SD	
01-Jul-97 14:00:34	- - -	- - -	- - -	PS	
01-Jul-97 14:00:36	- - -	- - -	- - -	PS	
01-Jul-97 14:00:38	- - -	- - -	- - -	PS	
01-Jul-97 14:00:40	- - -	- - -	- - -	PS	
01-Jul-97 14:00:42	- - -	- - -	- - -	PS	
01-Jul-97 14:00:44	- - -	- - -	- - -	PS	
NPB-290	Version 1.0.0	CRC XXXX	SpO2 Limit:	30-100%	PR Limit: 100-180 bpm
TIME	%SpO2	PR (bpm)	PA	Status	
01-Jul-97 14:00:46	- - -	- - -	- - -	PS	
NPB-290	Version 1.0.0	CRC XXXX	SpO2 Limit:	80-100%	PR Limit: 100-180 bpm
TIME	%SpO2	PR (bpm)	PA	Status	
01-Jul-97 14:00:56	79*	59*	220	SL PL LB	
01-Jul-97 14:00:58	79*	59*	- - -	PS SL PL LB	

Figure 10-2: Real-Time Printout

Column Heading

NPB-290	Version 1.0.0	CRC XXXX	SpO2 Limit:	30-100%	PR Limit: 100-180 bpm
TIME	%SpO2	PR (bpm)	PA	Status	

To explain the printout it will be necessary to break it down to its key components. The first two lines of the chart are the Column Heading shown above. Every 25th line will be a Column Heading. A Column Heading is also printed whenever a value of the Column Heading is changed. There are three Column Heading lines shown in Figure 10-2. Using the top row as the starting point there are 25 lines before the second Column Heading is printed. The third Column Heading was printed because the SpO_2 limits changed from 30-100% to 80-100%.

Printout Source

NPB-290	Version 1.0.0	CRC XXXX	SpO2 Limit:	30-100%	PR Limit: 100-180 bpm
TIME	%SpO2	PR (bpm)	PA	Status	

Data in the highlighted box above represents the source of the printout, in this case the NPB-290.

Software Revision Level

NPB-290	Version 1.0.0	CRC XXXX	SpO2 Limit:	30-100%	PR Limit: 100-180 bpm
TIME	%SpO2	PR (bpm)	PA	Status	

The next data field tells the user the software level, (Version 1.0.0) and a software verification number (CRC XXXX). Neither of these numbers should change during normal operation. The numbers will change if the monitor is serviced and receives a software upgrade.

Alarm Limits

NPB-290	Version 1.0.0	CRC XXXX	SpO2 Limit:	30-100%	PR Limit: 100-180 bpm
TIME	%SpO2	PR (bpm)	PA	Status	

The last data field in the top line indicates the high and the low alarm limits for %SpO_2 and for the pulse rate (PR). In the example above, the low alarm limit for SpO_2 is 30% and the high alarm limit is 100%. Pulse rate alarm limits are 100 bpm (low), and 180 bpm (high).

Column Headings

NPB-290	Version 1.0.0	CRC XXXX	SpO2 Limit:	30-100%	PR Limit: 100-180 bpm
TIME	%SpO2	PR (bpm)	PA	Status	

Actual column headings are in the second row of the Column Heading line. Patient data, from left to right, are the time that the chart was printed, the current %SpO_2 value being measured, the current pulse rate in beats per minute (bpm), the current Pulse Amplitude (PA), and the operating status of the NPB-290.

Patient Data and Operating Status

Time Tag

TIME	%SpO2	PR (bpm)	PA	Status
01-Jul-97 14:00:58	100	120	220	

Time Tag represents a real-time clock in: Day, Month, Year and 24-hour clock. The clock is maintained by either AC or battery power. If date and time have to be changed, follow the procedure outlined in paragraph 10.7.

Patient Data

NPB-290	Version 1.0.0	CRC XXXX	SpO2 Limit:	30-100%	PR Limit: 100-180 bpm
TIME	%SpO2	PR (bpm)	PA	Status	
01-Jul-97 14:00:58	100	190*	220	PH	

Patient data and the operating status of the unit are highlighted in the patient data display. Parameter values are displayed directly beneath the heading for each parameter. In this example, the %SpO_2 is 100, and the pulse rate (PR) is 190 beats per minute. The asterisk (*) next to the 190 indicates that 190 beats per minute is outside of the alarm limits, indicated at the far-right end in the top row, for pulse rate. If no data for a parameter is available, three dashes (- - -) will be displayed in the printout.

The number under PA is an indication of pulse amplitude. The number can range from 0 to 254 and will typically range around 45. There are no alarm parameters for this value. It can be used for trending information and indicates a change in pulse volume, pulse strength, or circulation.

Operating Status

NPB-290	Version 1.0.0	CRC XXXX	SpO2 Limit:	30-100%	PR Limit: 100-180 bpm
TIME	%SpO2	PR (bpm)	PA	Status	
01-Jul-97 14:00:58	100	190*	220	PH	

The Status column indicates alarm conditions and operating status of the NPB-290. The PH in this example indicates a Pulse High alarm. The Status column can have as many as 4 codes displayed in one line of data. The status codes are listed in Table 10-2.

Table 10-2: Status Codes

Code	Meaning
AO	Alarm Off
AS	Alarm Silence
BU	Battery in Use
LB	Low Battery
LM	Loss of Pulse w/Motion
LP	Loss of Pulse
MO	Motion
PH	Pulse Rate High Limit Alarm
PL	Pulse Rate Low Limit Alarm
PS	Pulse Search
SD	Sensor Disconnect
SH	Sat High Limit Alarm
SL	Sat Low Limit Alarm
- - -	No Data Available
*	Alarm Parameter Being Violated

Note: A Sensor Disconnect will also cause three dashes (- - -) to be displayed in the patient data section of the printout.

10.5 NURSE CALL

An RS-232 Nurse Call signal can be obtained by connecting to the data port. This function is available only when the instrument is operating on AC power. The RS-232 Nurse Call will be disabled when the unit is operating on battery power.

The remote location will be signaled anytime there is an audible alarm. If the audible alarm has been turned off, or silenced, the RS-232 Nurse Call function is also turned off.

Pin 11 on the data port is the RS-232 Nurse Call signal and pin 10 is ground (see Figure 10-1). The voltage between pins 10 and 11 will be -5 volts DC to -12 volts DC or +5 volts DC to +12 volts DC depending on the option chosen in menu item 8. Whenever there is in an audible alarm, the output between pins 10 and 11 will reverse polarity.

An internal Nurse Call relay (pins 7, 8, and 15) provides dry contacts which can be used to signal a remote alarm. These contacts can be used if the instrument is operating on AC or on its internal battery. Pin 15 is common, pin 7 is normally open (N.O.), and pin 8 is normally closed (N.C). The rating of the contacts is shown in Table 10-4. Table 10-3 shows the state of the contacts for Alarm and No Alarm conditions, and for Instrument Off.

Table 10-3: Nurse Call Relay Pin States

Pin	No Alarm	Alarm	Instrument Off
7 N.O.	Open	Closed	Closed
8 N.C.	Closed	Open	Open

Table 10-4: Rating of Nurse Call Relay

Maximum Input Voltage	30 volts AC or DC (polarity is not important)
Load Current	120 mA continuous (peak 300 mA @ 100 ms)
Minimum Resistance	26 ohms to 50 ohms (40 ohms typical) during alarms
Ground Reference	Isolated Ground
Electrical Isolation	1500 volts

10.6 ANALOG OUTPUT

Analog outputs are provided for saturation, pulse rate, and a plethysmographic waveform. These outputs are available only if the monitor is operating on AC power.

The output voltage is 0.0 to +1.0 volts DC for all three parameters. A 1.0-volt DC output for saturation equals 100%, for pulse rate it equals 250 bpm, and for plethysmographic waveform it equals 255 pulse amplitude units (pau). The voltage will decrease as the values for these parameters decrease.

At power-up, after the completion of POST, a calibration signal will automatically be sent. This signal can be started manually by accessing menu item 14. The calibration signal will begin at 0.0 volts DC and hold that point for 60 seconds. It will then jump up to 1.0 volt DC and hold that value for 60 seconds. The third part of the calibration signal is a stair-step signal. The stair-step signal will start at 0.0 volts DC and increase up to 1.0 volt DC in 0.10-volt increments. Each increment will be held for 1 second.

10.7 INTERACTIVE MODE

Introduction

When the NPB-290 is connected to a PC through the data port, the Interactive Mode is accessible. If the Interactive Mode has been accessed, real-time serial output is stopped and serial input is accepted. The user can request printouts and set date and time through the use of the PC and the data port.

Accessing the Interactive Mode

The Interactive Mode can be accessed when the data port of the NPB-290 is connected with a serial cable to a PC. Paragraph 10.3 describes the pin outs and how to build a serial cable.

The Interactive Mode can be accessed from a standard keyboard on a PC by holding the control key down and pressing "C" twice. The PC monitor will display the five options that are available in the Interactive Mode. The five options are:

1. Dump Instrument Info
2. Set Date and Time
3. Dump Trend
4. Dump Error Log
5. Exit Interactive Mode

Interactive Mode Options

Pressing the corresponding number on the PC keyboard accesses options.

Option 1) Dump Instrument Info

Menu item 2 (Trend Clear), described in paragraph 4.3.3, allows the user to delete the most recent trend data. Deleted trends can still be retrieved from the instrument through an Instrument Info printout.

The Instrument Info printout (when connected to a printer) or PC display (when connected to a PC) will show the oldest deleted trend as Trend 01. If a Trend 01 already exists in memory from an earlier Delete, the next deleted trend will become Trend 02. Every time a trend is deleted the number of existing trends will increase by 1. The most recently deleted trend will have the largest trend number.

Figure 10-3 illustrates an Instrument Info printout. The first two lines are the Column Heading lines. Line one is for instrument type, software revision level, type of printout, and alarm parameter settings. The second line contains the column headings. A line of data is recorded for every 2 seconds of instrument operation. Up to 24 hours of instrument operation data can be recorded.

The final line on the printout is Output Complete. This indicates that data has been successfully transmitted with no corruption. If there is no Output Complete printed, the data should be considered invalid.

This option is intended for Mallinckrodt field service personnel.

```
NPB-290      Version 1.0.0.000    Instrument     SpO2 Limit:   30-100%      PR Limit: 100-180 bpm
TIME         Trend 01     %SpO2   PR (bpm)   PA     SpO2 Status                User Interface Status


01-Jul-97  14:00:00        - - -     - - -    - - -    SD                      BU  LB    AO      L
01-Jul-97  14:00:02        - - -     - - -    - - -       PS                   BU  LB    AO
01-Jul-97  14:00:04        100       120      220                              BU  LB
01-Jul-97  14:00:06        100       120      220                              BU  LB
NPB-290      Version 1.0.0.000    Instrument     SpO2 Limit:   80-100%      PR Limit:  60-180 bpm
TIME         Trend 02     %SpO2   PR (bpm)   PA     SpO2 Status                User Interface Status   A
01-Jul-97  14:24:24        79*       58*      220    PS      SL  PL              BU  LB              M
01-Jul-97  14:24:26        79*       57*      220    PS      SL  PL              BU  LB  AS          M
01-Jul-97  14:24:28        0*        0*       - - -  PS  LP  SL  PL              BU  LB  AS          H
NPB-290      Version 1.0.0.000    Instrument     SpO2 Limit:   80-100%      PR Limit:  60-180 bpm
TIME         Trend 03     %SpO2   PR (bpm)   PA     SpO2 Status                User Interface Status


11-Jul-97  7:13:02         99        132*     220                PH            BU                  M
11-Jul-97  7:13:05         99        132*     220                PH            BU                  M
11-Jul-97  7:13:07         99        132*     220                PH            BU                  M
11-Jul-97  7:13:09         99        132*     220                PH            BU                  M
11-Jul-97  7:13:11         99        132*     220                PH            BU                  M
11-Jul-97  7:13:13         99        132*     220                PH            BU                  M
11-Jul-97  7:13:15         99        132*     220                PH            BU                  M
Output Complete
```

Figure 10-3: Instrument Info Printout

Option 2) Set Date and Time

When the instrument is sent from the factory, the date and time that have been entered are for Pacific Standard Time. If the battery has been disconnected or changed, the real-time clock will not reflect the actual time. For either of these reasons, it will be necessary to set the date and time. Selecting option 2 allows these settings to be entered from the PC keyboard.

The format for date and time is DD-MMM-YY HH:MM:SS. The hours, minutes, and seconds are entered in the 24-hour format. Move the cursor to the value that needs to be changed and enter the new value.

Option 3) Dump Trend

A Trend printout will include all data recorded for up to 24 hours of monitoring since the last trend delete was performed. A trend line is recorded every 2 seconds or whenever an alarm condition has occurred. The final line on the printout is Output Complete. This indicates that data has been successfully transmitted with no corruption. If there is no Output Complete printed, the data should be considered invalid. Figure 10-4 is an example of a Trend printout.

NPB-290 Version 1.0.0.000		TREND	SpO2 Limit: 30-100%	PR Limit: 100-180 bpm
TIME	%SpO2	PR (bpm)	PA	
01-Jul-97 14:00:00	100	120	220	
01-Jul-97 14:00:02	100	124	220	
01-Jul-97 14:00:04	100	190	220	
01-Jul-97 14:00:06	100	190	220	
01-Jul-97 18:00:43	- - -	- - -	- - -	
01-Jul-97 18:00:45	- - -	- - -	- - -	
NPB-290 Version 1.0.0.000		Trend	SpO2 Limit: 80-100%	PR Limit: 60-180 bpm
Time	%SpO2	PR (bpm)	PA	
01-Jul-97 18:00:53	- - -	- - -	- - -	
01-Jul-97 18:00:55	- - -	- - -	- - -	
01-Jul-97 18:01:57	98	100	140	
01-Jul-97 18:01:59	98	181*	190	
01-Jul-97 18:02:01	99	122	232	
Output Complete				

Figure 10-4: Trend Printout

Option 4) Dump Error Log

A list of all the errors recorded in memory can be obtained by selecting Error Log Dump. The first two lines are the Column Headings lines. The type of instrument producing the printout, software level, type of printout, and the time of the printout are listed in the first line. The second line is printout column headings. The final line on the printout is Output Complete. This indicates that data has been successfully transmitted with no corruption. If there is no Output Complete printed, the data should be considered invalid. An example of an Error Log printout is shown in Figure 10-5.

This option is intended for Mallinckrodt field service personnel.

NPB-290 Version 1.0.0.000		Error Log	Time:	14600:00:07
Op Time	Error	Task	Addr	Count
10713:21:03	52	12	48F9	100
00634:26:01	37	4	31A2	3
Output Complete				

Figure 10-5: Error Log Printout

SECTION 11: TECHNICAL SUPPLEMENT

11.1 Introduction
11.2 Oximetry Overview
11.3 Circuit Analysis
11.4 Functional Overview
11.5 AC Input
11.6 Power Supply PCB Theory of Operation
11.7 Battery
11.8 User Interface
11.9 Front Panel Display PCB and Controls
11.10 Schematics Diagrams

11.1 INTRODUCTION

This Technical Supplement provides the reader with a discussion of oximetry principles and a more in-depth discussion of NPB-290 circuits. A functional overview and detailed circuit analysis is supported by block and schematic diagrams. The schematic diagrams are located at the end of this supplement.

11.2 OXIMETRY OVERVIEW

The NPB-290 is based on the principles of spectrophotometry and optical plethysmography. Optical plethysmography uses light absorption technology to reproduce waveforms produced by pulsatile blood. The changes that occur in the absorption of light due to vascular bed changes are reproduced by the pulse oximeter as plethysmographic waveforms.

Spectrophotometry uses various wavelengths of light to qualitatively measure light absorption through given substances. Many times each second, the NPB-290 passes red and infrared light into the sensor site and determines absorption. The measurements that are taken during the arterial pulse reflect absorption by arterial blood, nonpulsatile blood, and tissue. The measurements that are obtained between arterial pulses reflect absorption by nonpulsatile blood and tissue.

By correcting "during pulse" absorption for "between pulse" absorption, the NPB-290 determines red and infrared absorption by pulsatile arterial blood. Because oxyhemoglobin and deoxyhemoglobin differ in red and infrared absorption, this corrected measurement can be used to determine the percent of oxyhemoglobin in arterial blood: SpO_2 is the ratio of corrected absorption at each wavelength.

11.2.1 Functional versus Fractional Saturation

The NPB-290 measures functional saturation, that is, oxygenated hemoglobin expressed as a percentage of the hemoglobin that is capable of transporting oxygen. It does not detect significant levels of dysfunctional hemoglobins. In contrast, hemoximeters such as the IL482 report fractional saturation, that is, oxygenated hemoglobin expressed as a percentage of all measured hemoglobin, including measured dysfunctional hemoglobins.

Consequently, before comparing NPB-290 measurements with those obtained by an instrument that measures fractional saturation, measurements must be converted as follows:

$$\text{functional saturation} = \text{fractional saturation} \times \frac{100}{100-(\%\ \text{carboxyhemoglobin} + \%\text{methemoglobin})}$$

11.2.2 Measured versus Calculated Saturation

When saturation is calculated from a blood gas measurement of the partial pressure of arterial oxygen (PO_2), the calculated value may differ from the NPB-290 SpO_2 measurement. This is because the calculated saturation may not have been corrected for the effects of variables that can shift the relationship between PaO_2 and saturation.

Figure 11-1 illustrates the effect that variations in pH, temperature, partial pressure of carbon dioxide (PCO_2), and concentrations of 2,3-DPG and fetal hemoglobin may have on the oxyhemoglobin dissociation curve.

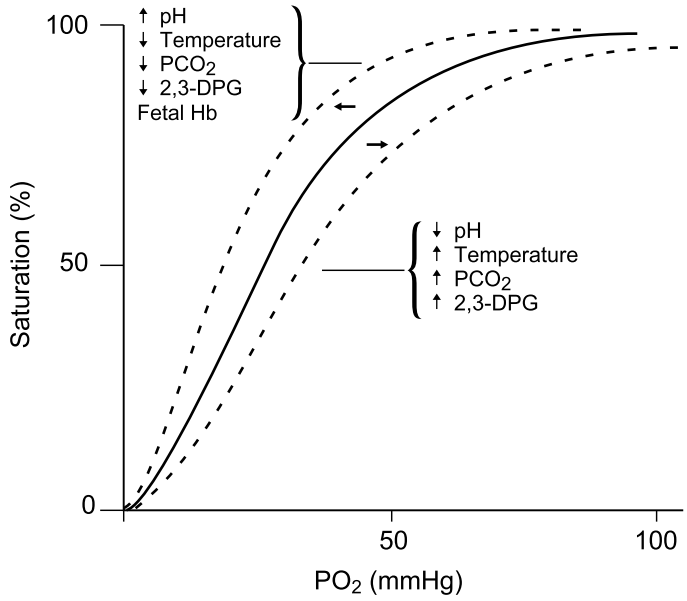

Figure 11-1: Oxyhemoglobin Dissociation Curve

11.3 CIRCUIT ANALYSIS

The following paragraphs discuss the operation of each of the printed circuit boards within the NPB-290 pulse oximeter. (Refer to the appropriate schematic diagram at the end of this section, as necessary.)

11.4 FUNCTIONAL OVERVIEW

The monitor functional block diagram is shown in Figure 11-2. Most of the functions of the NPB-290 are performed on the User Interface PCB. Functions on the User Interface PCB include the SpO_2 module, PIC, CPU, and Memory. Other key components of the NPB-290 are the Power Entry Module (PEM), Power Supply, and the Display printed circuit board (PCB).

The Display module consists of the LED display and the Membrane Panel. Contained on the Membrane Panel are annunciators and push buttons, allowing the user to access information and to select various available parameters. The Display PCB contains SpO_2, heart rate, and Blip Bar LEDs, and their associated driver circuits.

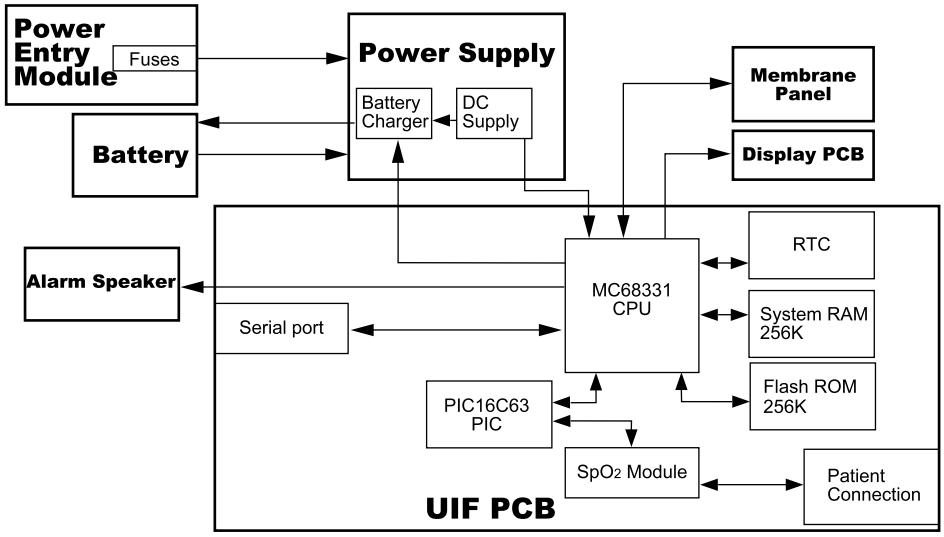

Figure 11-2: NPB-290 Functional Block Diagram

11.5 AC INPUT

A selector switch on the back of the NPB-290 allows the user to connect the monitor to AC power ranging from 100 volts AC to 240 volts AC. The switch has two positions, one for 100 volts AC through 120 volts AC and one for 200 volts AC through 240 volts AC. Verify that the switch selection matches the AC power at your location before plugging the monitor into an AC outlet.

AC power enters the NPB-290 through the Power Entry Module (PEM). A 0.5-amp fuse protects both the "Line" and "Neutral" lines. These user-accessible fuses are located in a fuse drawer, which is part of the PEM located on the back of the monitor.

11.6 POWER SUPPLY PCB THEORY OF OPERATION

The NPB-290 uses an unregulated linear power supply. This Power Supply provides the DC power needed to charge the battery and to power the User Interface PCB. Electro Static Discharge (ESD) protection is also provided by the power supply.

AC power from the PEM is passed through a step-down transformer, T2, which has two primary and two secondary windings. If switch SW1 on the back of the monitor is in the 120 VOLTS AC position, the primary windings are in parallel. The primary windings are in series if SW1 is in the 240 VOLTS AC position.

Each secondary winding is fused with a 2.0-amp fuse (F1 and F2). If a short circuit should occur in the DC circuitry, these fuses prevent the transformer from overheating. The output of the transformer varies, depending on load and input. Voltage measured between the outlet of a secondary winding and ground can be from 6 to 20 volts AC. High frequency noise from the AC line and from the User Interface PCB is filtered by C6 and C8 before passing through the bridge rectifier.

The bridge rectifier provides the DC power used in the NPB-290. The positive output is the MAIN_DC ranging from 7 to 18 volts DC. This positive voltage is used for the battery circuit and to power the User Interface PCB.

11.6.1 Battery Circuits

Two circuits are included in this section of the Power Supply PCB. One circuit is used to charge the battery, and the other circuit provides battery protection.

Charging Circuit

The power supply will charge the battery any time the NPB-290 is connected to AC power even if the monitor is not turned on. The voltage applied to the battery is 6.8 ± 0.15 volts DC and is current limited to 400 ± 80 mA.

Battery Protection

Two types of battery protection are provided by the power supply: protection for the battery and protection from the battery.

Switch SW2 is a resettable component that protects the battery. Switch SW2 opens and turns the charging circuit off if the temperature of the battery rises above 50° C. If the output of the battery exceeds 2.5 amps, F3 opens. Fuse F3 protects the battery from a short to ground of the battery output. Fuse F3 cannot be reset.

Protection from the battery is provided in case the battery is connected backwards. Should this happen, the output of the battery is shorted to ground through CR1 on the User Interface PCB. This provides protection for other circuits in the monitor.

11.7 BATTERY

A lead-acid battery is used in the NPB-290. It is rated at 6 volts DC, 4 amphours. When new and fully charged, the battery will operate the monitor for 8 hours. A new battery will last 15 minutes from the time the low battery alarm is declared until the unit is shut down due to battery depletion.

The battery can withstand 400 charge/discharge cycles. Recharging the battery to full capacity takes 14 hours in standby and 18 hours if being used.

Changing from AC to battery power will not interrupt the normal monitoring operation of the NPB-290. When the unit is running on battery power, the data port will be turned off along with the RS-232 Nurse Call. The Nurse Call relay will remain active.

11.8 USER INTERFACE PCB

The user interface PCB is the heart of the NPB-290. All functions except the unregulated DC power supply, display, and keypad reside on the user interface PCB. The following text covers the key circuits of the user interface PCB.

11.8.1 Regulated DC Power Supply

The User Interface PCB receives the MAIN_DC unregulated voltage of 7 to 18 volts DC from the power supply, or 5.8 to 6.5 volts DC from the internal battery. The power supply on the User Interface PCB generates +10.0, -5.0, and +5.0 volts DC.

11.8.2 Controlling Hardware

There are two microprocessors on the User Interface PCB. The CPU is a Motorola MC68331CF (331). The second microprocessor PIC16C63 is referred to as the PIC and is controlled by the CPU.

CPU

The 331 is the main controller of the NPB-290. The 331 controls the front panel display, data storage, instrument status, sound generation, and monitors and controls the instrument's power. The 331 also controls data port communication, the Nurse Call feature, and analog output.

Battery voltage is checked periodically by the processor. A signal from the processor turns the charging circuit off to allow this measurement to be taken. If the processor determines that the battery voltage is below 5.85 ± 0.1 volts DC, a low battery alarm is declared by the PIC. If battery voltage on the User Interface PCB is measured below 5.67 ± 0.1 volts DC, the monitor will display an error code and sound an audible alarm. (Voltages measured at the battery will be slightly higher than the values listed above.) The user will be unable to begin monitoring a patient if the battery voltage remains below this point. If either event occurs, plug the unit into an AC source for 14 hours to allow the battery to fully recharge.

When the NPB-290 is powered by AC, the RS-232 Nurse Call function is available. If no audible alarm conditions exist, the output will be -5 to -12 volts DC or +5 volts DC to +12 volts DC. These voltages are dependent upon the option selected in menu item 8. Should an audible alarm occur, the output would change polarity.

The 331 also controls a set of dry contacts provided by a relay on the User Interface PCB. The relay will function normally on AC power or on the internal battery power.

When the CPU sends a tone request, three items are used to determine the tone that is sent by the PIC to the speaker. First, pulse tones change with the %SpO_2 value being measured. The pulse beep tone will rise and fall with the measured %SpO_2 value. Second, three levels of alarms, each with its own tone, can occur: high, medium, and low priority. Third, the volume of the alarm is user adjustable. Alarm volume can be adjusted from level 1 to level 10, with level 10 being the highest volume.

User's interface includes the front panel display and the keypad. By pressing any of six keys on the keypad the operator can access different functions of the NPB-290. The 331 will recognize the keystroke and make the appropriate change to the monitor display to be viewed by the operator. Any changes made by the operator (i.e. alarm limits, pulse beep volume) are used by the monitor until it is turned off. Default values will be restored when the unit is turned back on.

Patient data is stored by the NPB-290 and can be downloaded to a printer through the data port provided on the back of the monitor. An in-depth discussion of the data port is covered in the Section 10 of this manual.

PIC Microprocessor

The PIC controls the SpO_2 function and communicates the data to the 331.

A pulse width modulator (PWM) function built into the processor controls the SpO_2 function. PWM signals are sent to control the intensity of the LEDs in the sensor and to control the gain of the amplifiers receiving the return signals from the photodetector in the sensor.

Analog signals are received from the SpO_2 circuit on the User Interface PCB. An A/D (Analog to Digital) function in the PIC converts these signals to digital values for %SpO_2 and heart rate. The values are sent to the 331 to be displayed and stored.

11.8.3 Sensor Output/LED Control

The SpO_2 analog circuitry controls the red and infrared (IR) LEDs such that the received signals are within the dynamic range of the input amplifier. Because excessive current to the LEDs will induce changes in their spectral output, it is sometimes necessary to increase the amplification of the received signal channel. To that point, the PIC controls both the current to the LEDs and the amplification in the signal channel.

At initialization of transmission, the LED intensity level is based on previous running conditions, and the transmission intensity is adjusted until the received signals match the range of the A/D converter. If the LEDs reach maximum output without the necessary signal strength, the PWMs will increase the channel gain. The PWM lines will select either a change in the LED current or signal gain, but will not do both simultaneously.

The LED drive circuit switches between red and IR transmission and disables both for a time between transmissions in order to provide a no-transmission reference. To prevent excessive heat buildup and prolong battery life, each LED is on for only a small portion of the duty cycle. Also, the frequency of switching is well above that of motion artifact and not a harmonic of known AC transmissions. The IR transmission alone, and the red transmission alone, will each be on for about one-fifth of the duty cycle; this cycle is controlled by the PIC microprocessor.

11.8.4 Input Conditioning

Input to the SpO_2 analog circuit is the current output of the sensor photodiode. In order to condition the signal current, it is necessary to convert the current to voltage.

Because the IR and red signals are absorbed differently by body tissue, their received signal intensities are at different levels. Therefore, the IR and red signals must be demodulated and then amplified separately in order to compare them to each other. Demultiplexing is accomplished by means of two circuits that alternately select the IR and red signal. Two switches that are coordinated with the IR and red transmissions control selection of the circuits. A filter with large time constant follows to smooth the signal and remove noise before amplification.

11.8.5 Signal Gain

The separated IR and red signals are amplified so that their DC values are within the range of the A/D converter. Because the received IR and red signals are typically at different current levels, the signal gain circuits provide independent amplification for each signal as needed. The gain in these circuits is adjusted by means of the PWM lines from the PIC.

After the IR and red signals are amplified, they are filtered to improve the signal-to-noise ratio and clamped to a reference voltage to prevent the combined AC and DC signal from exceeding an acceptable input voltage from the A/D converter.

11.8.6 Variable Gain Circuits

The two variable gain circuits are functionally equivalent. The gain of each circuit is contingent upon the signal's received level and is controlled to bring each signal to approximately 3.5 volts. Each circuit uses an amplifier and one switch in the triple single-poll double-throw (SPDT) analog-multiplexing unit.

11.8.7 AC Ranging

In order to measure a specified level of oxygen saturation and to still use a standard type combined processor and A/D converter, the DC offset is subtracted from each signal. The DC offsets are subtracted by using an analog switch to set the mean signal value to the mean of the range of the A/D converter whenever necessary. The AC modulation is then superimposed upon that DC level. This is also known as AC ranging.

Each AC signal is subsequently amplified such that its peak-to-peak values span one-fifth of the range of the A/D converter. The amplified AC signals are then filtered to remove the residual effects of the PWM modulations and, finally, are input to the PIC. The combined AC and DC signals for both IR and red signals are separately input to the A/D converter.

11.8.8 Real-Time Clock (RTC)

Real time is tracked by the NPB-290. As long as battery power or AC power is available, the instrument will keep time. If the battery is removed, the time clock will have to be reset.

11.8.9 Storage of Patient Data

Whenever the NPB-290 is turned on, it stores a "data point" in memory every 2 seconds (regardless of whether the NPB-290 is monitoring a patient or not). Up to 50 alarm limit changes will also be stored in trend data. The NPB-290 can store up to 24 hours of trend data. The 24 hours of stored trend data are available for downloading to *Score* software for 45 days. There are no limitations on displaying or printing data.

Caution: Changing alarm limit settings uses up trend memory space. Change alarm limits only as needed.

Note: Trend memory always contains the MOST RECENT 24 hours of data, with newly collected data over-writing the oldest data on a rolling basis. The NPB-290 continues to record data points as long as the monitor is powered on, with "blank" data points collected if no sensor is connected to the monitor or patient. "Blank" data will over-write older patient data if the memory becomes full. Therefore, if you want to save old patient data, it is important that you turn your monitor off when you are not monitoring a patient, and that you download the trend memory, using Score software, before it fills up and over-writes the old data with new data (or "blank" data).

Note: When using Score™ software use the latest version. Contact Mallinckrodt's Technical Services Department or your local Mallinckrodt representative to determine the latest version of Score software.

If battery power is disconnected or depleted, trend data and user settings will be lost. All data is stored with error detection coding. If data stored in memory is found to be corrupted, it is discarded.

11.9 FRONT PANEL DISPLAY PCB AND CONTROLS

11.9.1 Display PCB

Visual patient data and monitor status is provided by the Front Panel Display PCB. At power up, all indicators are illuminated to allow verification of their proper operation.

There are two sets of three 7-segment displays. One set displays %SpO_2 and the other displays pulse rate. A decimal point immediately to the right of either display indicates that an alarm limit for that parameter is no longer set at the power-on default value.

Between the two 7-segment displays is a 10-segment blip bar. The blip bar illuminates with each pulse beat. The number of segments illuminated indicates the relative signal strength of the pulse beat. A tone will accompany each pulse beat. The sound of the tone will change pitch with the %SpO_2 level being measured.

Five LEDs and icons are also located on the Front Panel Display PCB. An LED illuminated next to an icon indicates a function that is active. Functions indicated by the LEDs are AC/Battery Charging, Low Battery, Alarm Silence, Motion, and Pulse Search.

11.9.2 Membrane Keypad

A membrane keypad is mounted as part of the top case. A ribbon cable from the keypad passes through the top case and connects to the User Interface PCB. Six keys allow the operator to access different functions of the NPB-290.

These keys allow the user to select and adjust the alarm limits, cycle power to the unit, and to silence the alarm. Alarm volume and alarm silence duration can also be adjusted via the keypad. A number of other functions can be accessed by pressing the Upper and Lower Alarm Limit buttons simultaneously and then selecting the desired option with the Adjust Up or Adjust Down button. These functions are discussed in greater detail in Section 4.

11.10 SCHEMATIC DIAGRAMS

The following schematics are included in this section:

Figure 11-3: User Interface PCB Front End Red/IR Schematic Diagram
Figure 11-4: Front End LED Drive Schematic Diagram
Figure 11-5: Front End Power Supply Schematic Diagram
Figure 11-6: SIP/SOP Isolation Barrier Schematic Diagram
Figure 11-7: Data Port Drivers and Analog Output Schematic Diagram
Figure 11-8: User Interface PCB MC331 Core Schematic Diagram
Figure 11-9: User Interface PCB MC331 Memory Schematic Diagram B
Figure 11-10: Speaker Driver Schematic Diagram A
Figure 11-11: User Interface PCB Power Supply Schematic Diagram B
Figure 11-12: Display Interface Schematic Diagram
Figure 11-13: Parts Locator Diagram for USER INTERFACE PCB
Figure 11-14: Power Supply Schematic Diagram
Figure 11-15: Power Supply Parts Locator Diagram
Figure 11-16: Display PCB Schematic Diagram
Figure 11-17: Display PCB Parts Locator Diagram

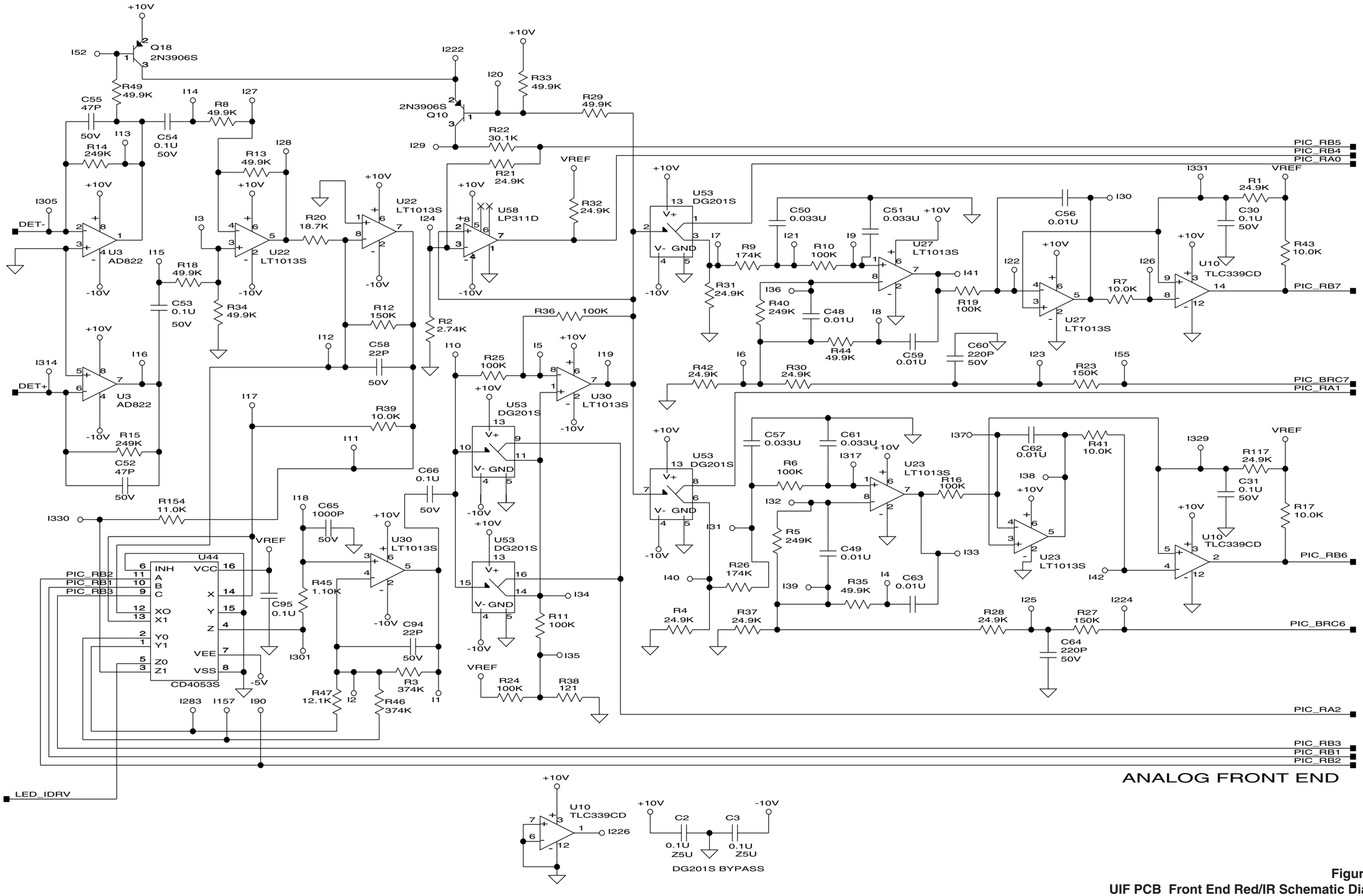

Figure 11-3
UIF PCB Front End Red/IR Schematic Diagram

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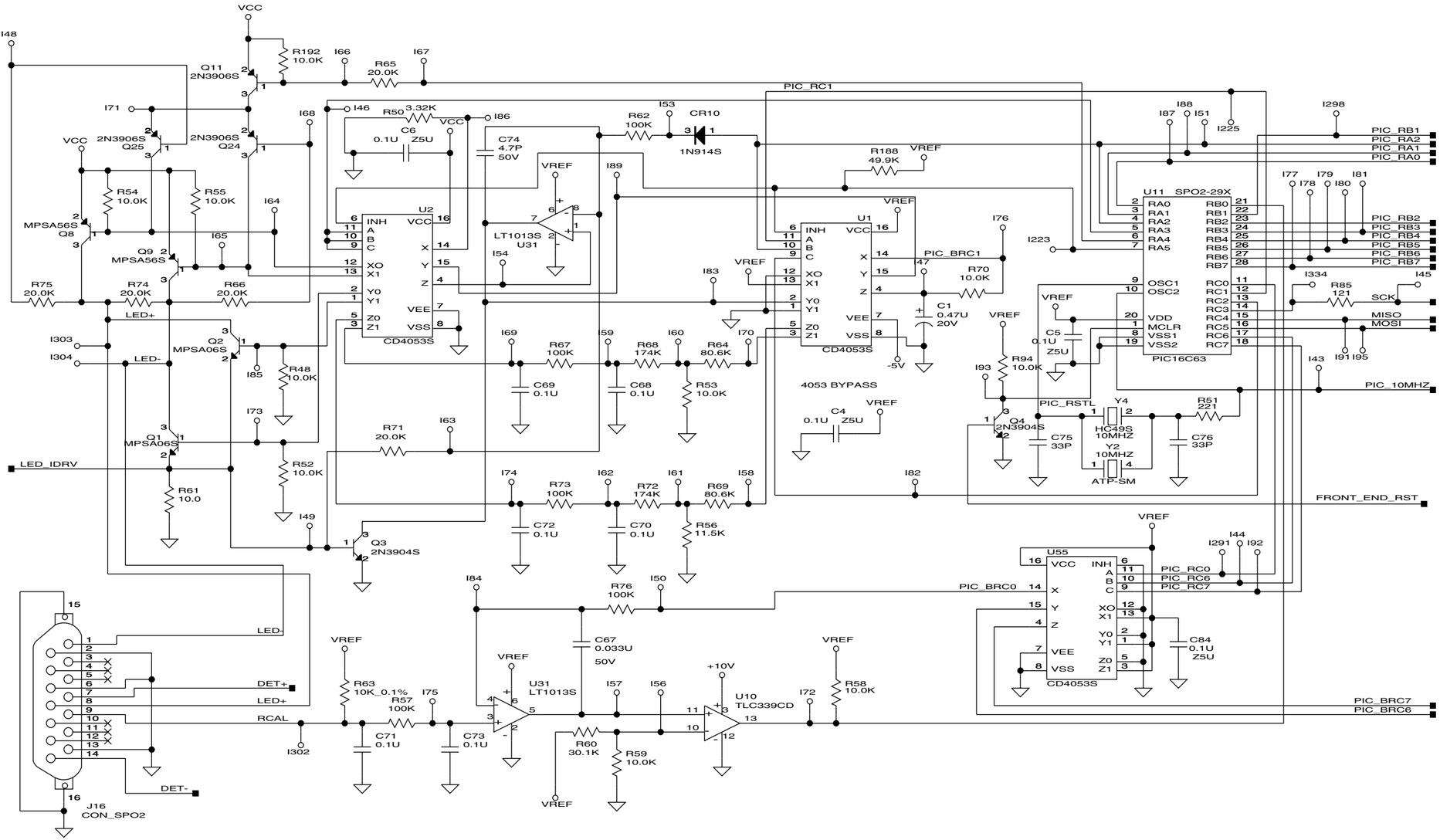

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Figure 11-4
Front End LED Drive Schematic Diagram

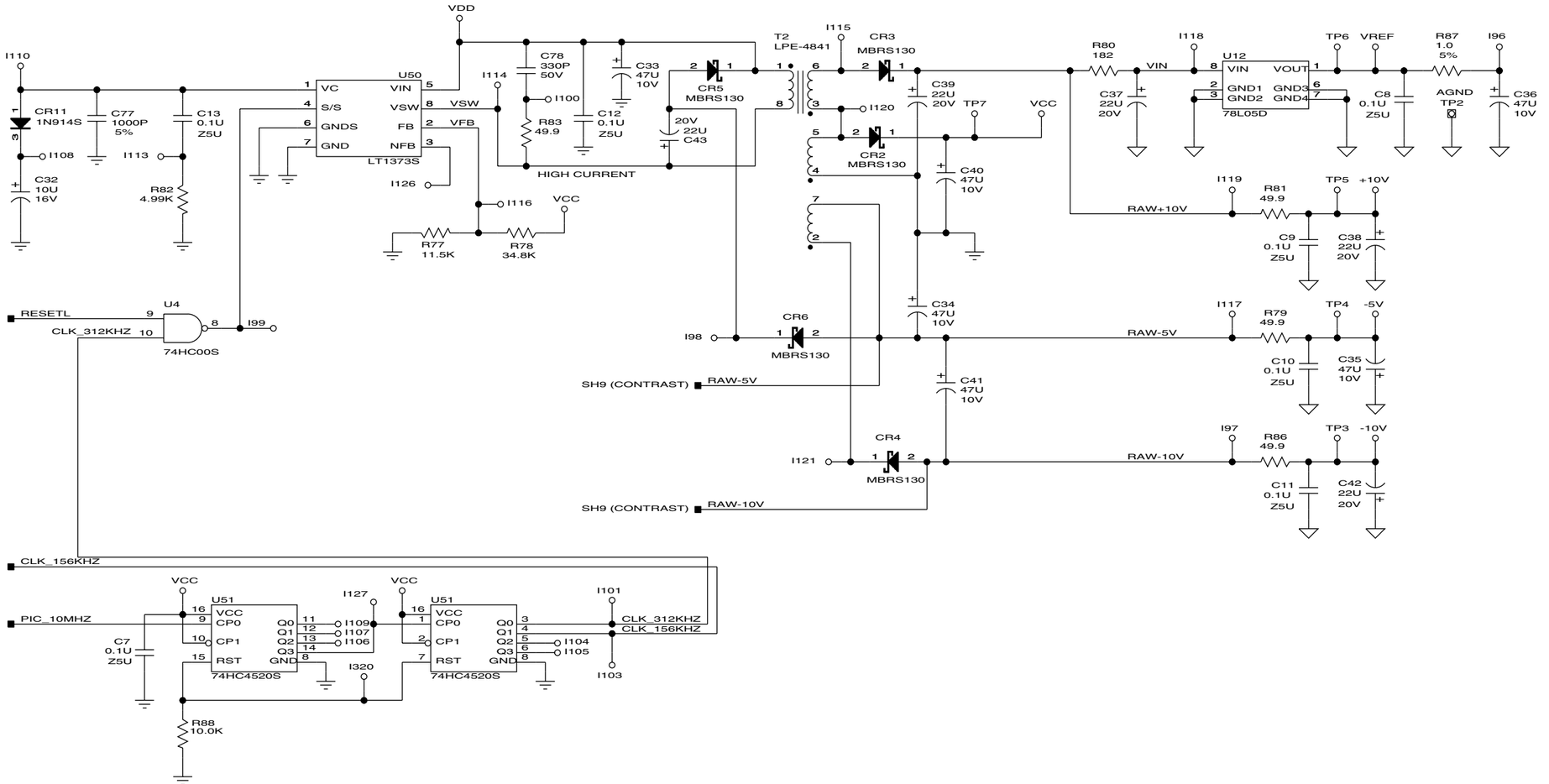

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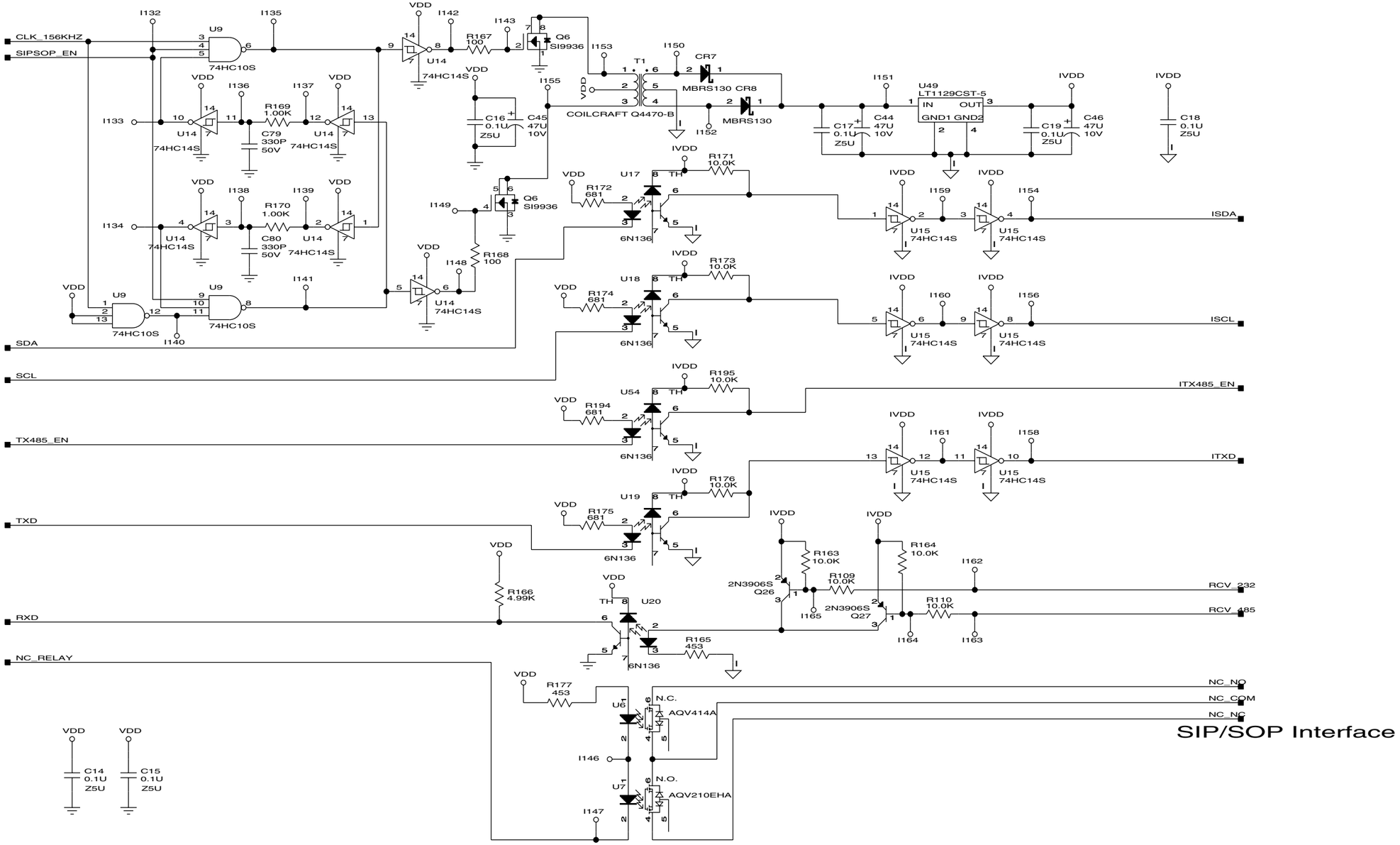
Figure 11-5
Front End Power Supply Schematic Diagram



SIP/SOP Interface

Figure 11-6
SIP/SOP Isolation Barrier Schematic Diagram

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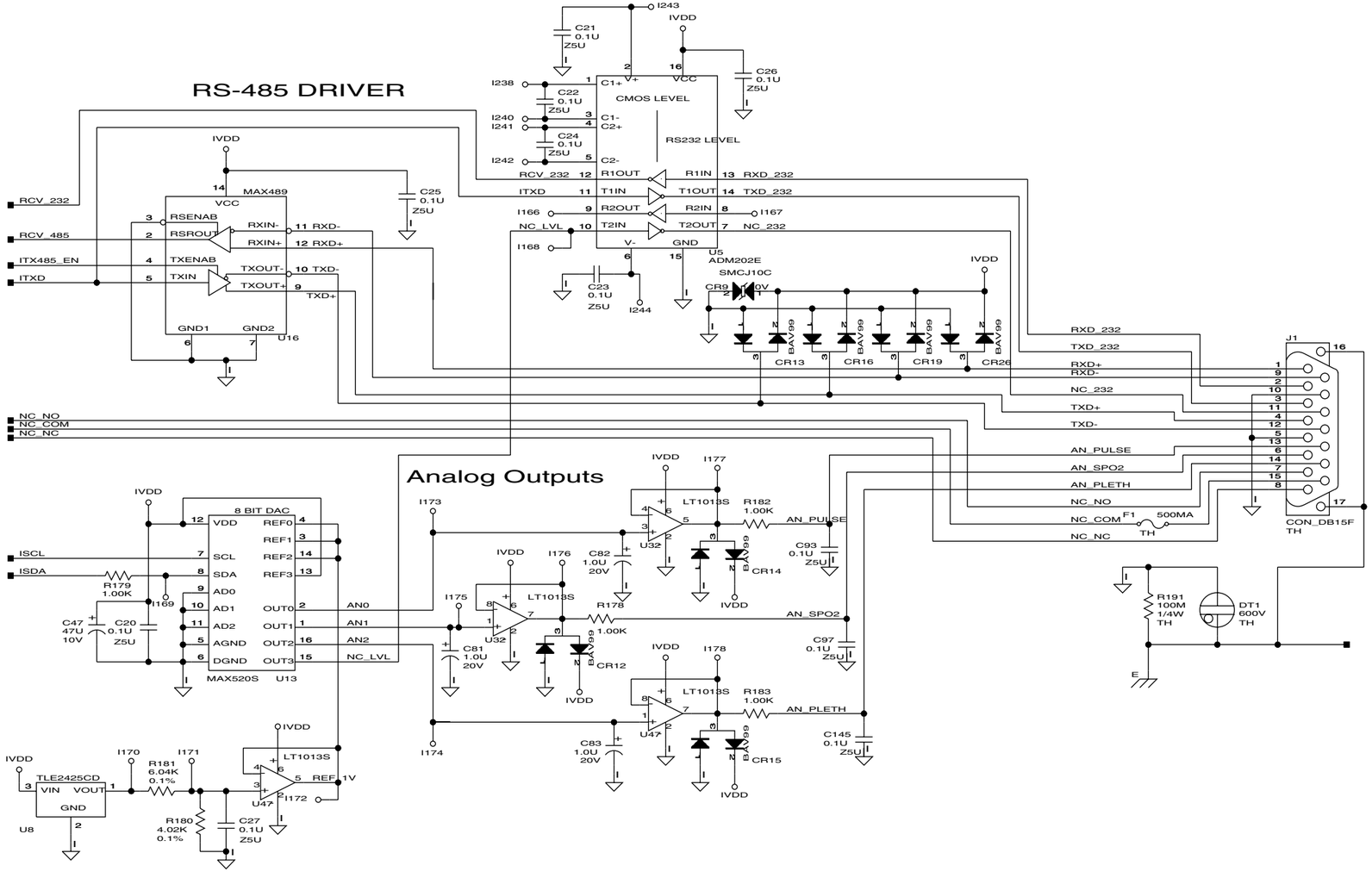

Figure 11-7
Data Port Drivers and Analog Output Schematic Diagram

035350

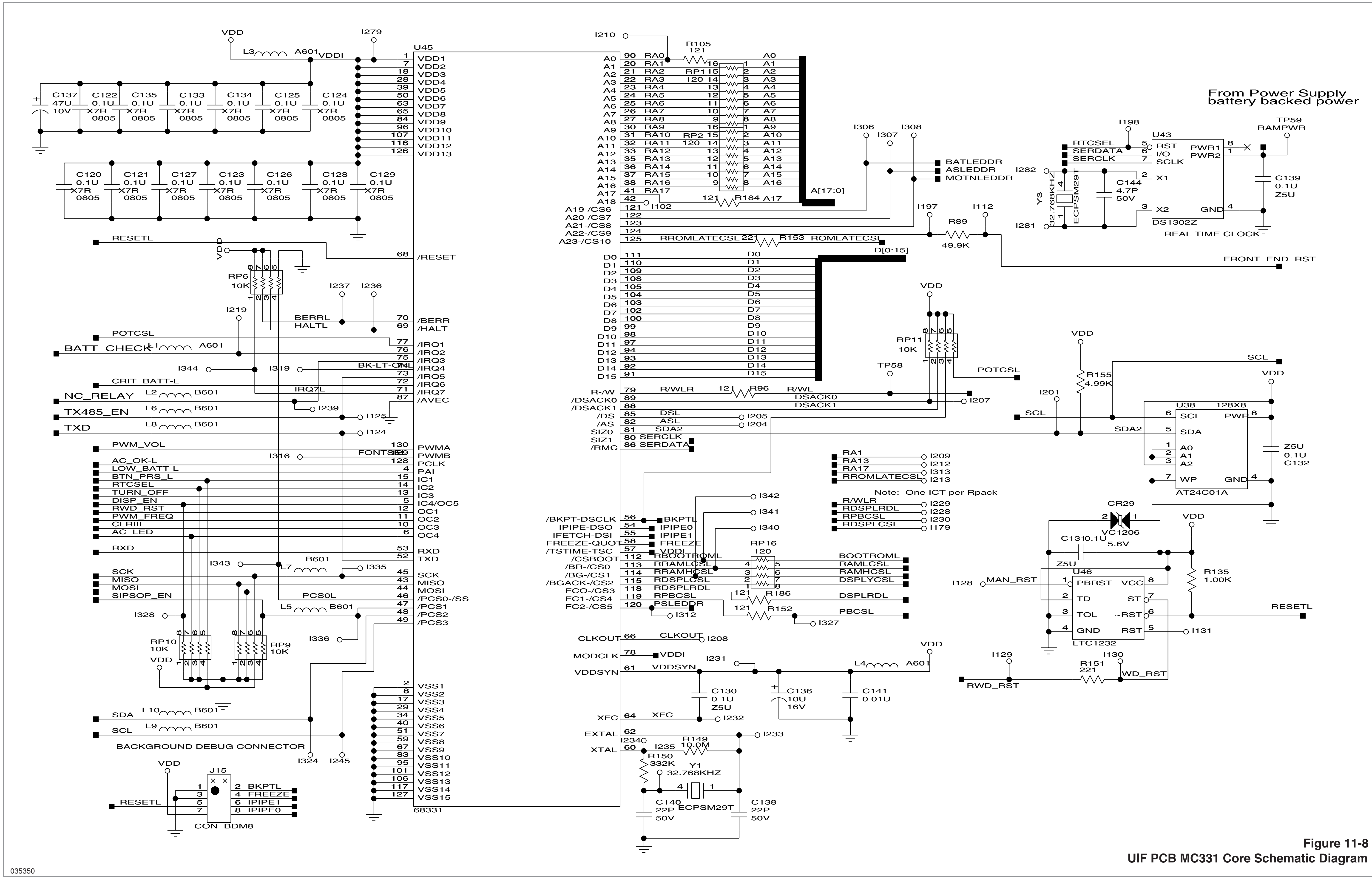

Figure 11-8
UIF PCB MC331 Core Schematic Diagram

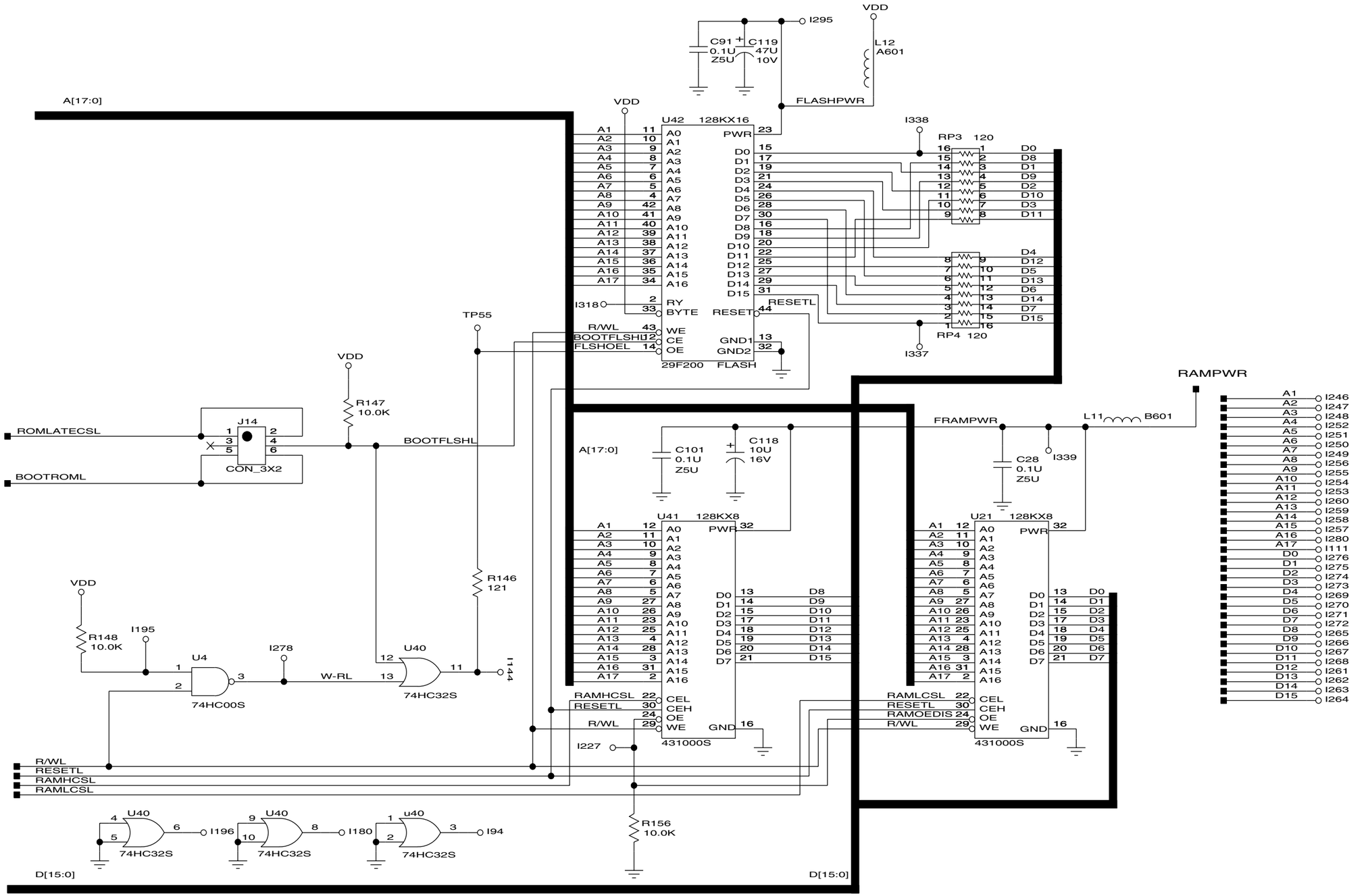

Figure 11-9
UIF PCB MC331 Memory Schematic Diagram B

035350

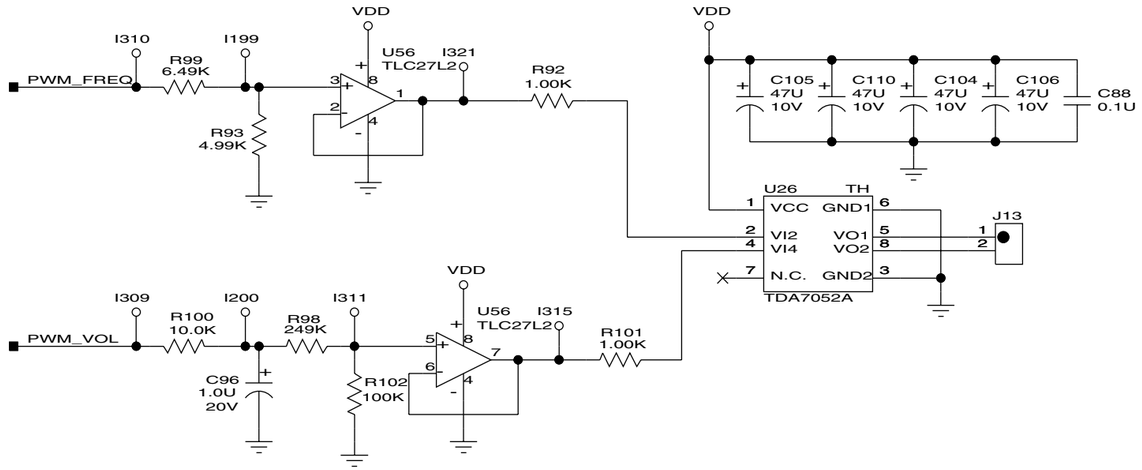

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Figure 11-10
Speaker Driver Schematic Diagram A

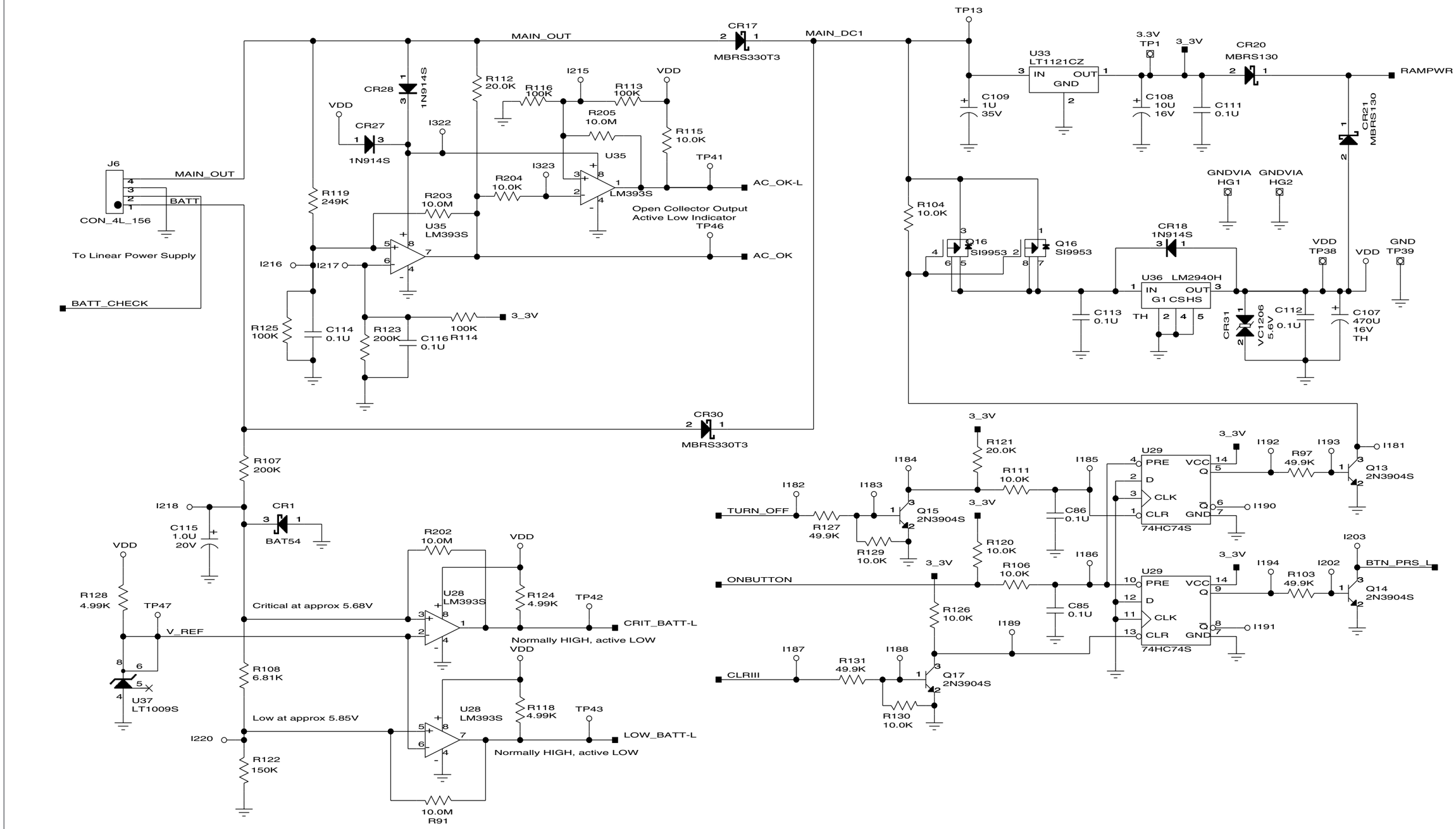

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Figure 11-11
UIF PCB Power Supply Schematic Diagram B

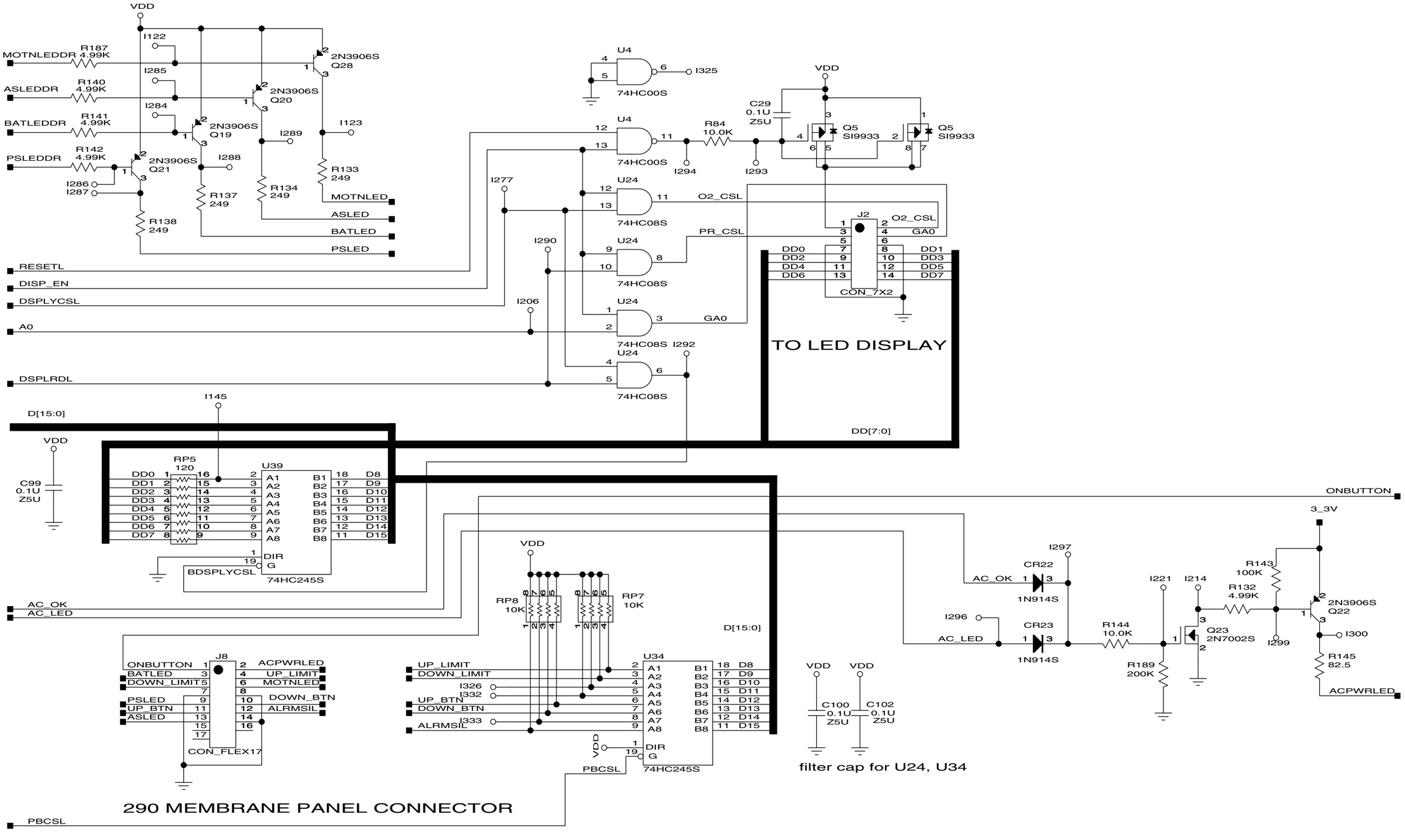
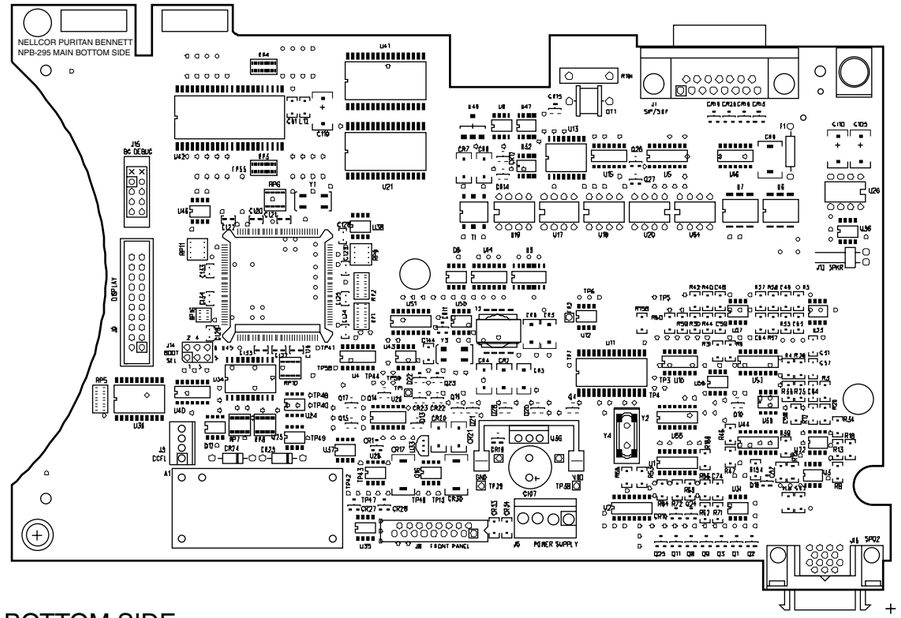
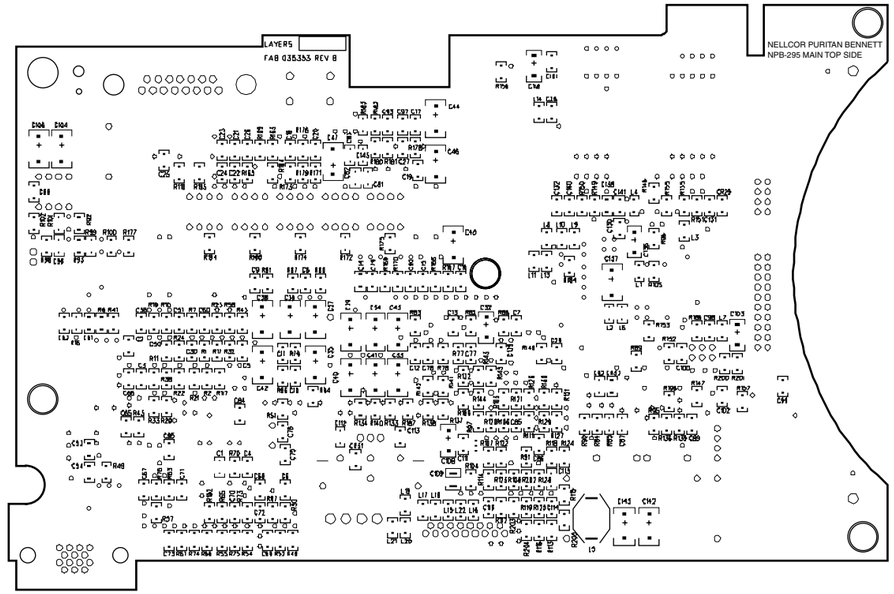


Figure 11-12
Display Interface Schematic Diagram

035350



BOTTOM SIDE



TOP SIDE

035355

Figure 11-13
Parts Locator Diagram for UIF PCB

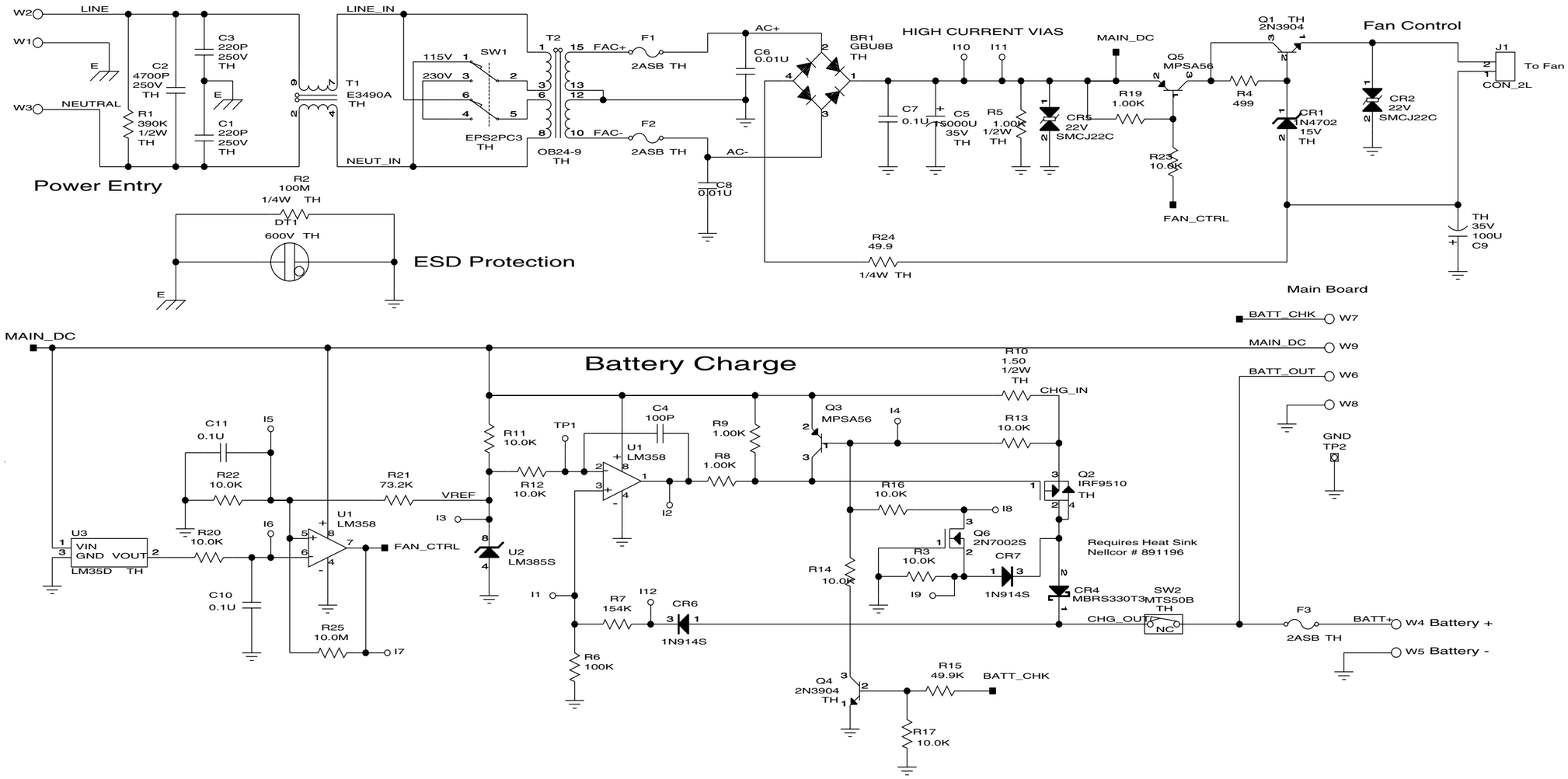


Figure 11-14
Power Supply Schematic Diagram

035199

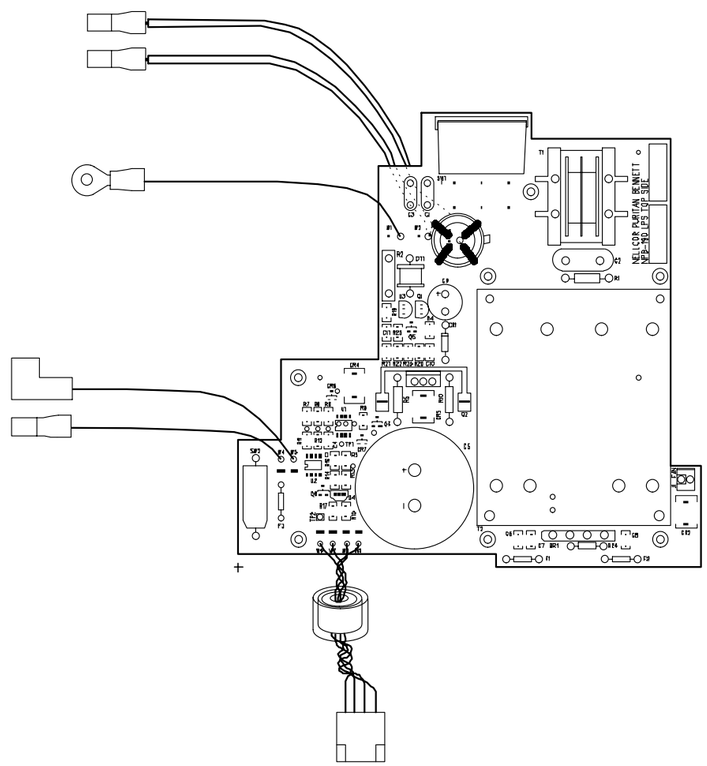


Figure 11-15
Power Supply Parts Locator Diagram

035200

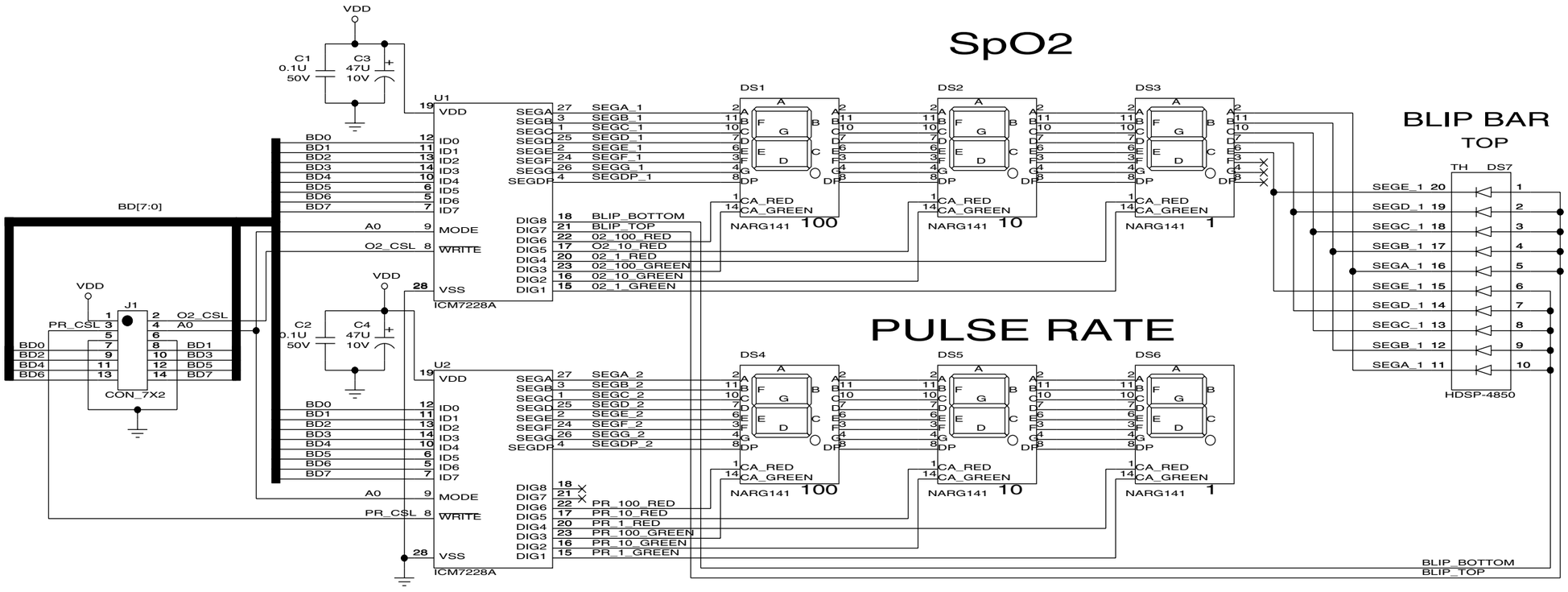


Figure 11-16
Display PCB Schematic Diagram

035346

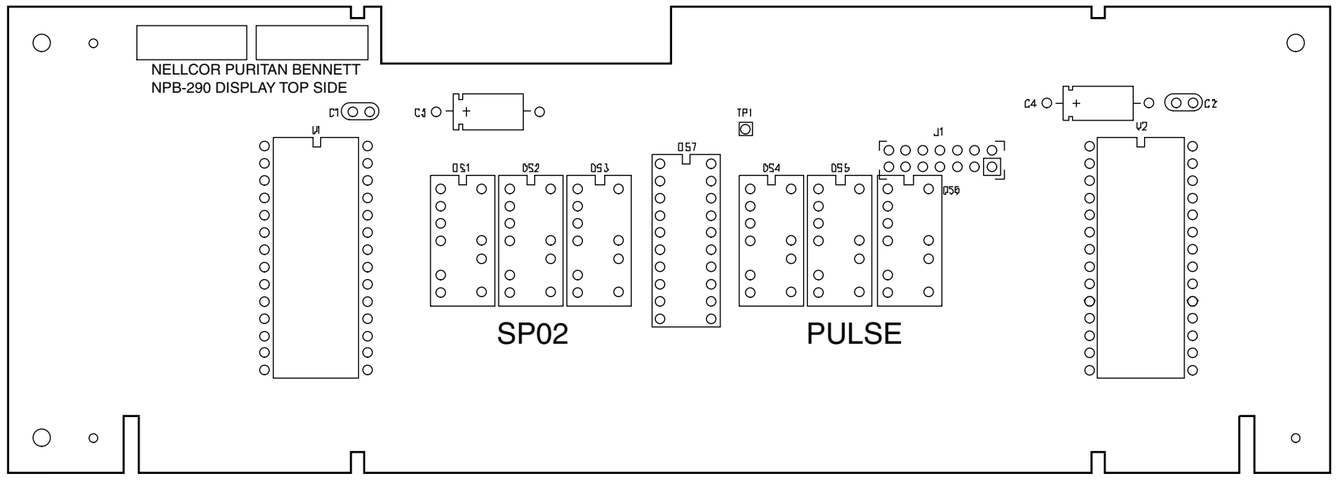


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Figure 11-17
Display PCB Parts Locator Diagram

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